CSIRO
AUSTRALIA

CSIRO Strategic Research Plan

1997–98 to 1999–2000

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CSIRO—the Commonwealth Scientific and Industrial Research Organisation—is a large and one of the most diverse scientific research institutions in the world. It has a staff of around 7,000 working in laboratories and field stations throughout Australia.

CSIRO is an independent statutory authority constituted and operating under the provisions of the *Science and Industry Research* Act 1949.

CSIRO's vision

To be a world class research organisation vital to Australia's future.

Explore CSIRO on the Web at: http://www.csiro.au

This edition (August 1997) supersedes the edition published in July 1997 (undated) which contained errors in the Charts on pages 88, 108, 114, 146, 147 and 148. Some other minor modifications have also been made.

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Message from the Chairman

This Strategic Research Plan reflects a new approach to the way in which CSIRO is structured and manages its business.

The new approach had its origin in March 1996 with the implementation of a fundamental reorientation of CSIRO's management and structure. Those changes reflect a purposeful redefinition of the way CSIRO identifies, plans, conducts and markets its research. They reinforce the notion that CSIRO is a single entity whose diverse skills can be coordinated and harnessed to meet particular economic, environmental, societal or scientific needs.

The Plan results from the extensive work done over the past year by staff throughout the Organisation in consultation with the two hundred or so members of our Sector Advisory Committees. The Plan is set in the context of some overall national considerations arising from our dialogue with Commonwealth Government Departments.

The Plan has the full support of the Board. The Board has noted the caveats from the Sector Advisory Committees that the planned outcomes and proposed sectoral research portfolios are subject to ongoing assessment and refinement of priorities. In particular the Board notes that further redirections are required and will be achieved by 1999-2000 to realise the desired increases for the Marine and Petroleum Sectors and the decrease in the building material component of the Built Environment Sector.

Plans are but a beginning. They serve to set the goals and show the way. The hard but exciting work required to achieve the outcomes is before us. Therein lies the challenge, both for our staff and our stakeholders. Together we can do the excellent science and ensure its uptake to meet the opportunities facing Australia and to help shape its future.

Charles K Allen AO
June 1997

Contents

The Way Ahead

The 1996 Sector Outlook Forum and the 1995 Annual Business Review highlighted CSIRO's impressive breadth of scientific achievement and diverse contributions to the nation. While breadth and diversity have obvious merit, there was a concern that, in some areas, CSIRO may have spread its resources too thinly across too wide a range of activities. Hence the emphasis in the sector planning process has been on focus and selectivity.

Looking to the next three to five years, CSIRO must make a concerted effort to secure the benefits that accrue from building strong, interdisciplinary teams that are internationally competitive, of critical size, and which address issues where research and development can best contribute to the national well-being. This means building on its proven capability, lifting its game where necessary and delivering the benefits of excellent R&D broadly throughout the Australian community.

The sector planning process has provided the organisation with a major opportunity to reshape its efforts in this way and to generate new and exciting R&D programs directed towards outcomes of major benefit to Australia. The Executive will continue to encourage Divisions to develop and enhance inter-Divisional links so that this opportunity is not lost.

CSIRO has sought to focus on those areas where there are firm signals of strong interest and market and/or community support for its research. CSIRO cannot, by research alone, maintain industries or industry activities which suffer deteriorating economic circumstances or where major industry restructuring is needed. Nor can it achieve sound environmental and social outcomes without community support and appropriate government policies.

With the help of the sector advisory committees, and within the context of the national overview (see box) provided through the Government-CSIRO Workshop held in February 1997, CSIRO must continually identify those points at which its involvement can make the greatest contribution to each sector. For the production based sectors, CSIRO intends to strengthen further its philosophy of taking a holistic view along the chain from resource to industry to end user, to judge where R&D can make the greatest contribution.

CSIRO expects society's demand for ecologically sustainable development and quality environmental values, both on the land and in our oceans, to continue. CSIRO intends to enhance the resources for its national interest role to a small but important extent in the marine area.

A National Overview

The second Government-CSIRO Workshop was held on 13 February 1997 in Canberra and involved sixty-four participants including representatives from twelve Commonwealth Departments, CSIRO's Sector Advisory Committees and CSIRO.

Main Messages

The presentations revealed coherence between the national policy objectives of the Government, as conveyed by Department representatives, and the broad strategic research direction of CSIRO.

Participants emphasised the importance of achieving:

- Strong and sustained economic growth through policies which promote innovation, raise national savings, keep inflation low and lead to higher productivity and lower unemployment;
- Internationally competitive industries responsive to the opportunities created through globalisation, trade liberalisation, deregulation and initiatives such as APEC;
- A more diverse economy which builds on Australia's comparative advantages including its proximity to growing markets and natural resources (value adding);
- Better integration of environmental goals and efficient economic production, with environmental sustainability as an integral part of industry success and community well-being;
- Improved living standards with much greater attention to areas such as clean, green production, and preventative health care; and
- An informed society which recognises the importance of education and scientific knowledge.

CSIRO's multi-disciplinary research capabilities and scientific expertise are needed to:

- Underpin economic development and the international competitiveness of Australian firms (small and large);
- Enhance industry's ability to adopt new technology;
- Enable a whole-of-system approach to key issues such as environment, health and transport;
- Support environmental initiatives on land and water such as addressed under the National Heritage Trust and the Oceans Policy;
- Provide expert advice to Government for policy formulation and at international fora on trade and environmental conventions; and
- Raise community awareness of scientific advancements leading to an informed debate over issues such as Genetically Modified Organisms (GMOs).

Some of the main specific messages included the importance of CSIRO's work on quarantine and climate change forecasting, and the importance of government facilitating introduction of GMOs. Techniques and technology to access and use information strategically were also highlighted.

Making it Work: the things we need to do

Seven themes guide CSIRO's strategic directions across all 22 sectors. Attention to each one is important in helping to maximise CSIRO's contributions to the nation.

1. Focus: real needs, realistic commitments

The sectoral approach to setting research priorities and conducting research programs will assist CSIRO in sharing its knowledge and in focusing its efforts. The continuing advice it seeks from its many stakeholders will help to ensure that what it does is relevant to real economic, social and environmental needs.

This focus on customers and sectoral needs does not imply a move away from basic research to an even greater emphasis on applied research. Rather, it recognises that strategic research makes an essential contribution in the longer term in the light of appropriate priorities and context.

Many of the sectoral advisory committees have strongly urged CSIRO to maintain, and in some cases enhance, its effort on strategic research as opposed to short-term contract research. They have expressed their concern that the external funding targets are becoming too high and may detract from the organisation's ability to fulfil its mission. CSIRO will monitor the situation.

There are some emerging areas, not clearly defined in CSIRO's current sectoral framework, where it may be useful in future to do more, or to refocus the work. At present CSIRO has insufficient evidence of the size or nature of these needs, or whether defining a new sector would be the best response—it will keep a watching brief.

Examples include the urban environment (with infrastructure and broad environmental links) and tourism and recreation (with services, IT and biodiversity links).

CSIRO judges that a number of industries are changing in ways that will considerably alter their research needs and their own capability to perform R&D. For example, the research capacity of the electricity supply, water and communication industries will be tested as they become more diversified and are privatised. CSIRO's interactions with them will need to adapt accordingly.

In several sectors, where CSIRO is working with large international companies, there is a continuing need to establish a clearly defined pathway of benefit to Australia from the research it does. In cases where such beneficial pathways do exist, or can be created, CSIRO will continue close interaction with them, both here and overseas.

2. Working with customers: creating value, delivering the goods

CSIRO's key legislated role is to carry out scientific research to assist Australian industry and further the interests of the Australian community. To do this successfully, CSIRO's efforts must not only focus on relevant issues, they must also be grounded in a capacity to listen to, and work with, the customers and end-users for whom research is being conducted. The sectoral approach will greatly assist CSIRO in strengthening this capacity. To foster the efficient delivery and effective application of new knowledge and improved technologies, CSIRO will continue to upgrade its commercial practices and will adopt flexible and responsive modes of working with customers.

3. Teamwork and collaboration: internal and external

CSIRO's core strength, which sets it apart from other research agencies, is the capacity to assemble and manage teams of highly skilled professionals from a wide range of disciplines. These teams may need to respond quickly to short-term crises or be devoted to long-term research into some of the most formidable scientific challenges. This capacity enables CSIRO, for example, to adopt an integrated 'whole systems' approach to the challenges of environmental management or to add value at all levels of a business system from raw material to final consumption.

The move to sector-based operations opens the door to many fresh opportunities for Divisional collaboration. This is likely to occur in relation to issues requiring teams with a range of skills, but also in strategic research to realise the benefits from an infusion of new ideas and expertise. Generic skills, such as genetic engineering, earth observation, software engineering, bioinformatics and risk assessment can contribute across a wide range of sectors. CSIRO expects that there will be tight networking of such skills across the organisation.

Inevitably, there will be overlapping interests across sectors. For some activities, environment sectors link tightly to production sectors which draw upon, or affect, the natural resource base. Sectors in the mining and energy area link naturally along a chain from the mine to the many uses of minerals. The skills and insights developed in the information technology and telecommunications (IT&T) sector are a resource for a growing number of applications in many other sectors.

One example of an integration of skills will illustrate the point. Australia now has an extended Exclusive

Economic Zone in its surrounding seas, and also a growing need for the energy lying in deep waters within that zone. In a conjunction of skills not found in any other single research agency, the several Divisional participants in CSIRO's marine and petroleum sectors will work closely together to seek ways to meet oil and gas industry research needs in offshore locations.

CSIRO must also actively seek further collaboration with other research performers and extension services, both public and private, that have complementary roles and expertise. The next few years will see continuation and consolidation of interactions beyond CSIRO, particularly through Cooperative Research Centres (CRCs). The management complexities of commitments to CRCs will continue to demand attention.

CSIRO expects to see an increase in interactions with State agencies, in some cases reflecting their new awareness of the importance of research, in other cases reflecting a budgetary-related weakening of their capacity to pursue research and extension activity.

Another aspect, becoming clearer, is the need to remove boundaries between the social sciences and the natural/physical sciences and engineering, whose combined insights are often required to discover solutions to complex problems and bring them to fruition. Rather than building up its limited in-house social and economic skills, CSIRO will improve its external access to these skills and work with others to direct its research towards wider policy and management needs.

4. Balance: knowledge creation and application

To remain vital and relevant to emerging challenges, CSIRO requires a balanced portfolio of projects based on short, medium and longer-term needs. Research timescales oblige it to be far-sighted, looking beyond the lifetime of individual governments or the investment cycle of many businesses. The Alliance forums should assist in this process, since advances in basic understanding generally will have applications across many sectors.

CSIRO's interactions with its customers and stakeholders must raise mutual awareness of what strategic research is needed to underpin future advances and of what is needed now to help solve immediate problems and create real economic and social benefit.

5. Excellence: quality people + quality processes = quality outcomes

CSIRO must continue to build on its commitment to excellence. CSIRO's reputation and capacity to fulfil its mission are founded on this commitment and a strong desire to be world-class.

This extends beyond excellence in science to excellence in every aspect of the organisation's endeavours, including staff training and development, research management and administrative support, customer relations, marketing and commercialisation. The sector plans reinforce this message by addressing these aspects specifically as well as the research objectives themselves.

6. Communication: managing change cooperatively

Change inevitably brings a measure of stress and discomfort for some of the individuals and groups affected by it—both within the organisation and externally. Effective communication is a critical ingredient if the positive benefits of change are to be maximised and the discomfort minimised.

CSIRO will endeavour to manage the necessary changes within the organisation in a compassionate and cooperative manner. The organisation has recognised a need to improve its internal communication and has begun implementing strategies to achieve this.

Communication will be regarded as an important line management responsibility. Managers will be assisted to develop the necessary skills and held accountable accordingly. Opportunities to enhance the role of formal and informal staff associations and professional groupings will be explored.

The new Public Awareness Program adds an important dimension to the continuing efforts of CSIRO staff at all levels in communicating CSIRO to its many customers and stakeholders.

7. Fiscal management: practising responsible stewardship

CSIRO must accept accountability for the resources entrusted to it—some $1.3 billion of government appropriation funds over the funding triennium. High priority will be placed on fixing current financial difficulties and establishing all Divisions and all corporate functions on a healthy financial footing. Maintaining standards of fiscal management appropriate to an organisation of CSIRO's stature will be a necessity at all levels of the organisation.

Although priority setting and planning occurs on a sectoral basis, the implementation and financial management of the commitments documented in sector plans will remain a Divisional responsibility.

Priorities, Processes and Roles

The plan envisages not only marginal and incremental changes between sectors over the next triennium but also a substantial reordering and focusing of priorities within sectors.

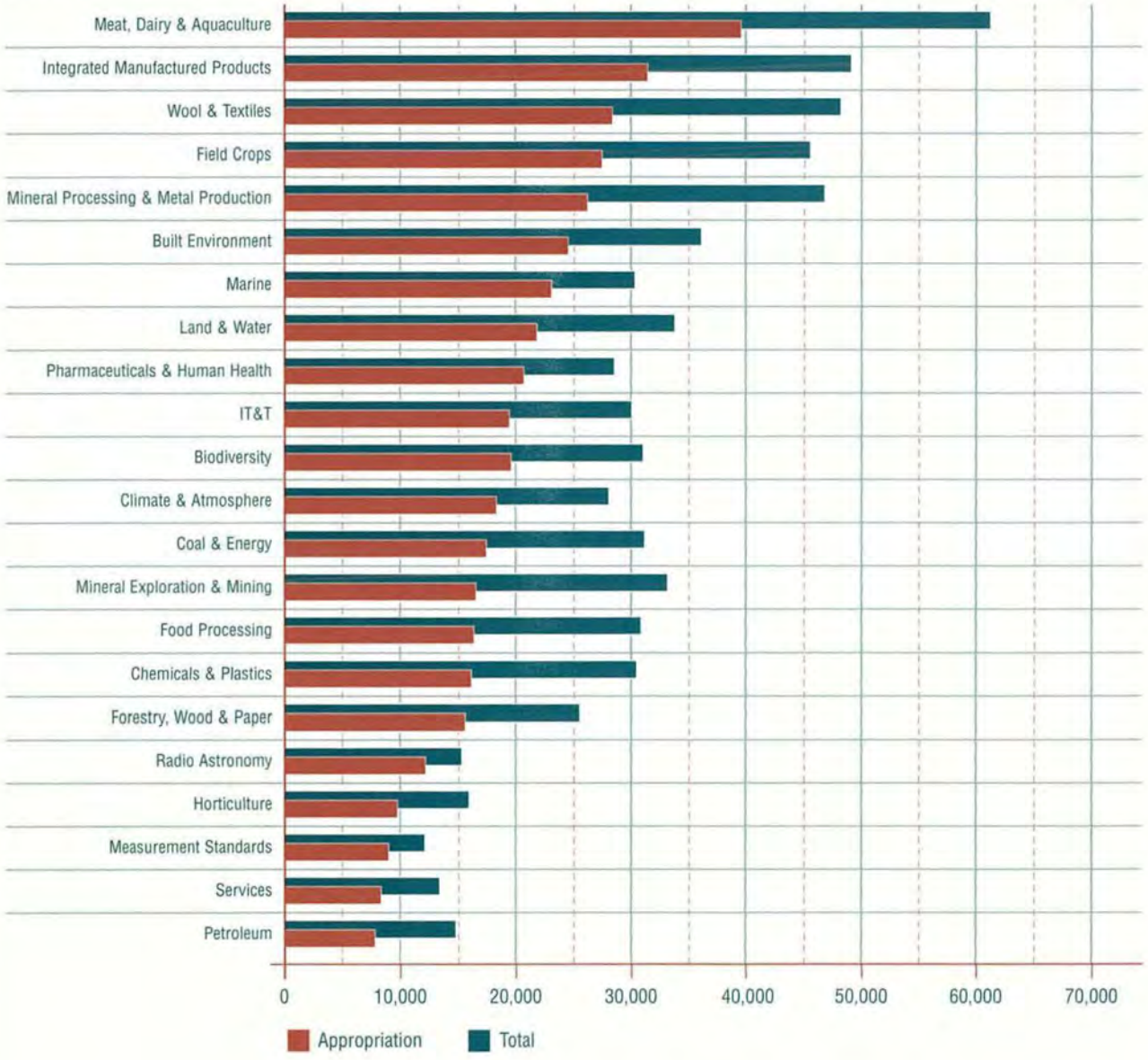
Specifically, the investment in R&D by 1999–2000 for the Marine Sector is targeted to grow by $1.5m pa; for the Petroleum Sector by $1.0m pa; and is targeted to decline by $1.0m pa for the Building Materials component of the Built Environment Sector. The overall priorities and investment picture is depicted in Table 1 and Chart 1.

Table 1: Planned CSIRO Investment by Sector, $'000, 1997–98 to 1999–2000

Sector	1997–98 Appropriation	1997–98 External	1998–99 Appropriation	1998–99 External	1999–2000 Appropriation	1999–2000 External	1999–2000 Share of Appropriation Investment	1999–2000 Share ot Total Investment	1999–2000 Anticiapted external ratio	EC target external ratio
1 Field Crops	25095	16454	26100	17537	26710	18684	6.2%	6.6%	41%	40%
2 Food Processing	15607	10719	16301	12281	16784	14023	3.9%	4.5%	46%	45%
3 Forestry, Wood & Paper	15128	9065	15832	9112	16189	9166	3.8%	3.7%	36%	38%
4 Horticulture	9136	5400	9531	5441	9736	5734	2.3%	2.3%	37%	40%
5 Meat, Dairy & Aquaculture	37298	21787	38914	21270	39813	21186	9.3%	8.9%	35%	40%
6 Wool & Textiles	26146	18443	27394	19264	28195	20230	6.6%	7.0%	42%	43%
7 Biodiversity	18596	11199	19126	11502	19480	11904	4.6%	4.6%	38%	35%
8 Climate & Atmosphere	18490	9032	18804	9263	18957	9351	4.4%	4.1%	33%	35%
9 Land & Water	20232	11573	20780	11730	21188	12044	5.0%	4.8%	36%	36%
10 Marine	20828	7565	22090	7936	21985	8238	5.1%	4.4%	27%	30%
11 IT&T	19639	8417	19475	9165	19501	10501	4.6%	4.4%	35%	35%
12 Built Environment	21850	10792	22882	12235	23173	12994	5.4%	5.3%	36%	38%
13 Measurement Standards	8155	2832	8596	2550	8857	2600	2.1%	1.7%	23%	30%
14 Radio Astronomy	11694	4730	11557	4215	11740	3235	2.7%	2.2%	22%	21%
15 Services	7903	3496	7902	3861	8247	4405	1.9%	1.8%	35%	33%
16 Chemicals & Plastics	14949	11305	15734	12343	16659	13823	3.9%	4.4%	45%	40%
17 Integrated Manufactured Products	31035	14023	30574	15488	31869	17414	7.4%	7.2%	35%	40%
18 Pharmaceuticals & Human Health	19294	7663	19879	7954	20281	7443	4.7%	4.0%	27%	30%
19 Coal & Energy	17308	12592	17887	12842	18341	13093	4.3%	4.6%	42%	40%
20 Mineral Explorn & Mining	16570	15407	17142	15811	16891	16053	3.9%	4.8%	49%	46%
21 Mineral Proc & Metal Prodn	23101	15639	25003	18571	25628	20779	6.0%	6.8%	45%	48%
22 Petroleum	7309	5755	7799	6173	7823	6472	1.8%	2.1%	45%	45%
TOTAL 22 SECTORS	**405362**	**233887**	**419301**	**246544**	**428046**	**259372**	**100%**	**100%**	**38%**	**39%**
Corporate Support Functions	40800	7300	39300	7200	40000	6700				
Alliance Summary										
I Agribusiness	128410	81868	134072	84905	137427	89023	32%	33%	39%	
II Environment & Natural Resources	78145	39368	80800	40431	81610	41538	19%	18%	34%	
III IT, Infrastructure & Services	69241	30266	70412	32026	71518	33735	17%	15%	32%	
IV Manufacturing	65277	32991	66187	35785	68808	38680	16%	16%	36%	
V Minerals & Energy	64289	49393	67830	53397	68683	5397	16%	18%	45%	

Chart 1: Planned CSIRO Investment by Sector, $'000, 1999–2000

(Sectors ranked by Appropriation Investment, excluding corporate support functions of $40 million Appropriation and $6.7 million External)



This does not mean that larger changes might not be justified over a 5 to 10 year horizon, but the Executive has judged that the greatest benefits in the next triennium can be achieved by a better targeting of the research effort within each sector.

Key common questions for sectors and their advisory committees

To help determine the sectoral priorities, each advisory committee and its participating divisions were asked to address a common set of key questions:

- On which elements of the sector should CSIRO's effort be focused, taking into account:
  - — relevance and need, evidenced by customer demand
  - — CSIRO's mandate vis-à-vis other research providers, both public and private
  - — the multidisciplinary capacity of CSIRO
  - — allowance for some speculative (often high risk) and opportunistic activities.
- With which particular groups of clients/stakeholders or their intermediaries should CSIRO interact to help ensure adoption of research results?
- What is the appropriate balance of effort across the segments within the sector? How should external and appropriation funding differ between these?
- Can the required skills be obtained from within CSIRO (e.g. by redeployment) rather than by hiring

new staff? This may require assessment of inter-sectoral priorities (via the Alliances) in cases where demand exceeds supply of particular skills.

The Executive's intention was to minimise the budgetary impact on Divisions. The Divisions, in consultation with sector partners and sector advisory committees, were asked to deploy their skill bases so as to achieve the desired outcomes.

The following points outline the key elements of the process that has led to the current set of sectoral plans. The process is shown in Chart 2 (p.xii) and the assessment framework is explained in detail in the Appendix.

- The Executive determined the desired level of CSIRO effort in each sector, from appropriation funds and external earnings, as an envelope for planning.
- An initial working assumption was that Divisional budget trends would be unchanged. *In situ* redeployment might be required, with inter-Divisional shifts used as a last resort.
- Planning should drive the budget, not the reverse.
- A key part of sector planning was the establishment of the components needed within a sector to achieve integration across Divisions and facilitate priority setting.
- Sector advisory committees were actively involved in the process, so that the emerging research portfolios reflect CSIRO's stakeholders' views, tested against its own.

Key Roles for Chiefs of Divisions and Sector Coordinators

The role of Sector Coordinators and Chiefs of Divisions should be seen in the context of the management structure and organisation philosophy introduced by CSIRO in 1996.

The key issue in such a two dimensional structure (Divisions and Sectors) is the relative responsibilities of the Chiefs of Divisions and Sector Coordinators. These are determined by a number of factors such as:

- commercialisation route and maturity of the business—what works for a stable mining sector may not be appropriate for a dynamic sector such as Information Technology and Telecommunications.
- process and diversity of customers—for the rural sector, Rural R&D Corporations interaction plays a key role in determining sector research programs, but other sectors are dominated by differing mixes of large companies and SMEs or have a strong public interest role.
- experience—over time, most organisations evolve and change the relative balance of influence between Divisions representing the skill base and Sectors representing the markets.

The use of the term "Coordinator" indicates the management of research and resources will continue to be through the Chiefs of Divisions. Sector Coordinators fulfil a staff role in facilitating and coordinating CSIRO efforts in support of particular sectors. The core roles of Sector Coordinator and Divisional Chief are outlined in the following table.

The operating and reporting arrangements are shown in Chart 3 (p.xiii).

Role/Function	Sector Coordinator	Chief of Division
Planning and Resource Allocation	■ With the Sector Advisory Committee and the Sector Chiefs develop the Sector 5–10 year Outlook and Sector Plan. This process will include — identifying key customers and analysing their R&D requirements — identifying strategic science and technology needs — identifying performance criteria. — developing the portfolio of projects in the light of these needs, and of government policy ■ Agree with Sector Chiefs on allocation of Sector resources across CSIRO for triennium.	■ Divisional planning and participation with Sector Coordinator and Sector Chiefs in Sector planning ■ Agree allocation of resources to fund Divisional commitments to Sector Plans.
Customer Liaison	■ Convene and provide appropriate input to Sector Advisory Committee to assist in planning. ■ Work with Sector Chiefs on external representation, business development, and distribution of responsibilities for account management.	■ Liaise with principal customers as agreed with Sector Coordinators and other Chiefs.
Monitoring and Reviewing	■ With Chiefs of Divisions monitor progress against Sector Plan.	■ With Sector Coordinators, monitor progress against Sector Plans, and with Project Managers, monitor contribution of Division to projects.
Management	■ Coordination role; no line management role. ■ Preparation, with Chiefs, of Sector Plans. ■ Coordinate post investment analysis of returns and assessment of outcomes. **Problem Resolution** ■ Through Chief of Division and DCE.	**Finance** ■ Full fiscal responsibility for revenue (through accrual accounting), capital equipment and asset/facility maintenance. **Human Resources** ■ Full line-management responsibility for recruiting, training, assessing, rewarding and developing careers. **Skill Development** ■ Full responsibility for establishing and developing appropriate expertise and scientific excellence. ■ Full responsibility for establishing appropriate balance of skills between applied and strategic work. ■ Maximise synergies between Divisions. **Safety** ■ Sole responsibility for ensuring safe-working at all times. **Benchmarking** ■ Full responsibility for maintaining quality of science and technology against competitors in the public sector (including academia), private sector providers where relevant. **Problem Resolution** ■ With Sector Coordinators and DCE, through line-management of Project Managers.
Marketing and Commercialisation	■ Coordination of Sector-based marketing and commercialisation plans in conjunction with Sector Chiefs.	■ Full line-management responsibility for delivering on Sector based marketing and commercialisation plans.
Accountability	■ To line manager (with input from Chiefs and Chairman of Sector Advisory Committee).	■ To DCE (with input from Sector Coordinators).

As approved 19 April 1996

Priorities, Processes and Roles

Chart 2: CSIRO Planning and Resource Allocation Process

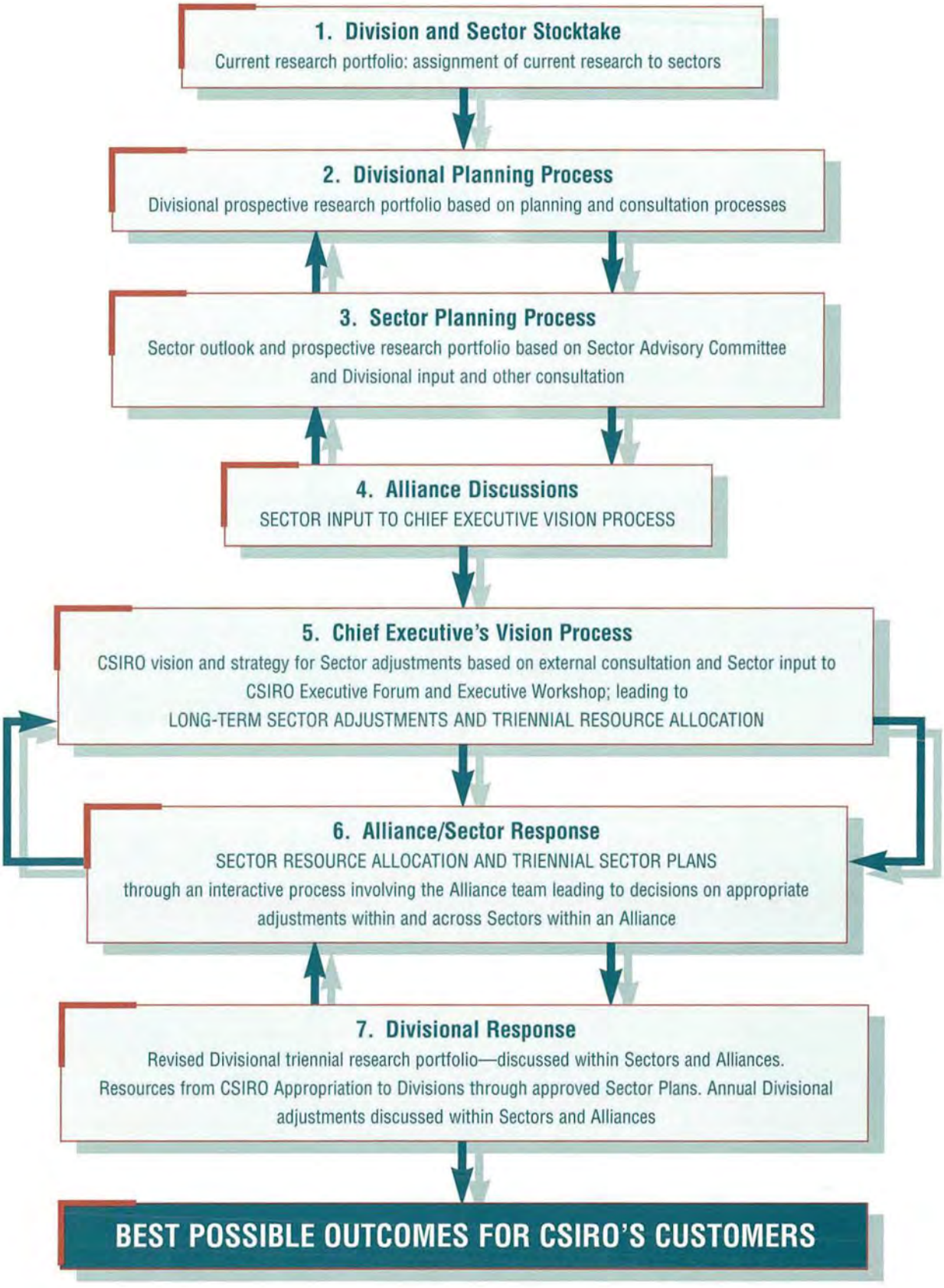
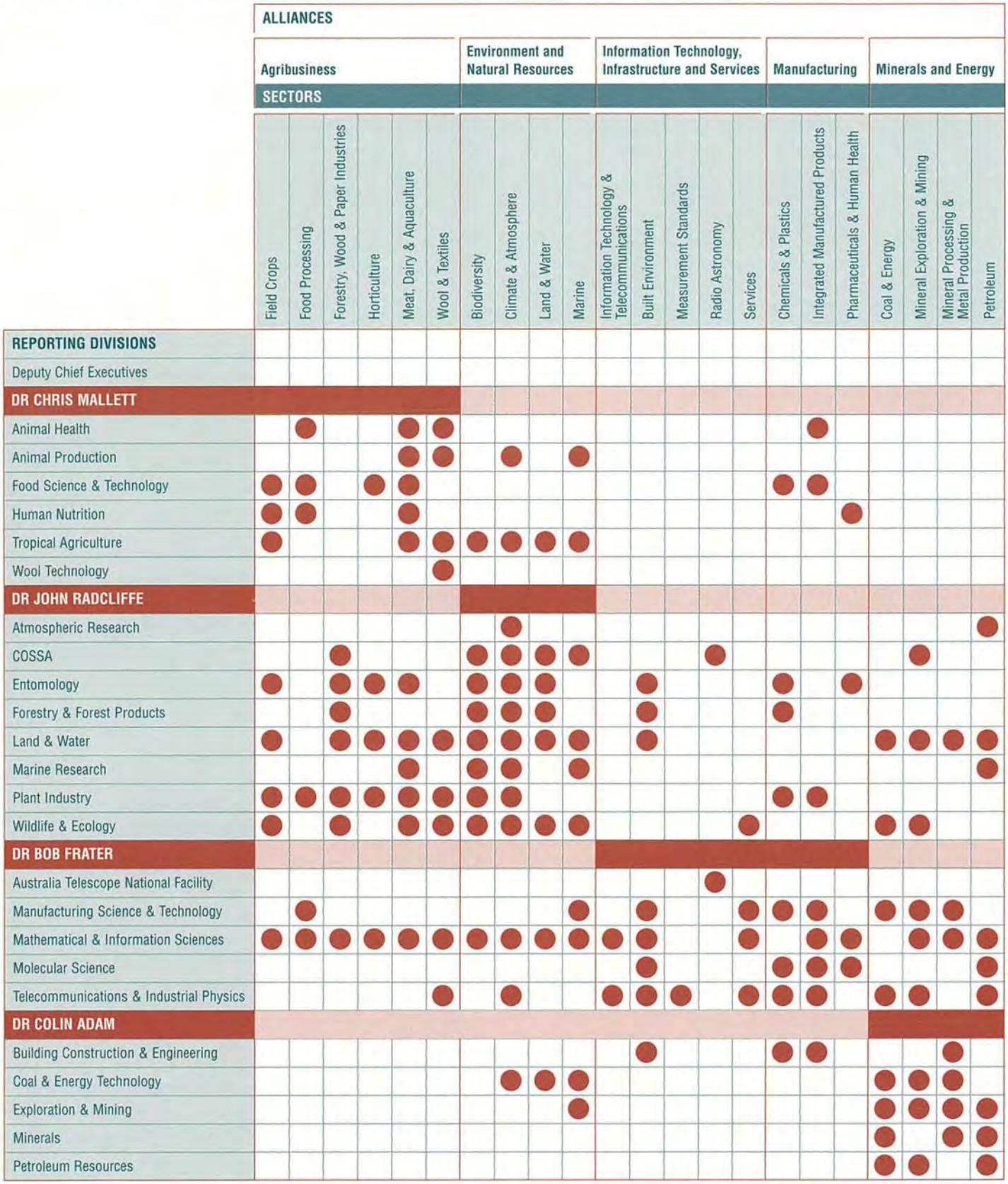


Chart 3: CSIRO Operations and Reporting

Chief Executive—Dr Malcolm McIntosh



List of Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ACARP	Australian Coal Association Research Program
ACIAR	Australian Centre for International Agricultural Research
ACSys	CRC for Advanced Computational Systems
AFISC	Australia Food Industry Science Centre
AFMA	Australian Fisheries Management Authority
AFTA-CER	ASEAN Free Trade Association—Closer Economic Relations
AGAL	Australian Government Analytical Laboratories
AGSO	Australian Geological Survey Organisation
AIMS	Australian Institute of Marine Science
AIP	Australian Institute of Petroleum
AMIRA	Australian Mineral Industries Research Association
ANCA	Australian Nature Conservation Agency
ANZSIC	Australia New Zealand Standard Industry Classification
APCRC	Australian Petroleum Cooperation Research Centre
APEC	Asia Pacific Economic Cooperation
APLAC	Asia-Pacific Laboratory Accreditation Program
APLMF	Asia-Pacific Legal Metrology Forum
APMP	Asia-Pacific Metrology Program
APPEA	Australian Petroleum Production and Exploration Association
APSRU	Agricultural Production Systems Research Unit
AQIS	Australian Quarantine Inspection Service
ASTEC	Australian Science and Technology Council
ATM	Asynchronous Transfer Mode
ATNF	Australia Telescope National Facility
BET	Built Environment Technology
BOM	Bureau of Meteorology
BRS	Bureau of Resource Sciences
CAD	Computer Aided Design
COSSA	CSIRO Office of Space Science and Applications
CRA	Comprehensive Regional Assessment
CRC	Cooperative Research Centre
CRP	Component Research Plan
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCE	Deputy Chief Executive
DEST	Department of Environment, Sports and Territories
DFAT	Department of Foreign Affairs and Trade
DIST	Department of Industry, Science and Tourism
DPIE	Department of Primary Industries and Energy
DSS	Decision Support Systems
DSTC	Distributed Systems Technology Centre
EC	Executive Committee
EEZ	Exclusive Economic Zone
EFT	Equivalent Full Time (staff)
EM	Electro Magnetic
EOC	Earth Observation Centre
ERDC	Energy Research & Development Corporation
EUROMET	European Collaboration in Measurement Standards
FTE	Full Time Equivalent (staff)
GaAs MMIC	Gallium arsenide Monolithic Microwave Integrated Circuits
GATT	General Agreement on Tariff and Trade
GBRMPA	Great Barrier Reef Marine Park Authority
GDP	Gross Domestic Product
GVP	Gross Value of Production
HACCP	Hazard Analysis and Critical Control Points
HBV	Hepatitis B Virus
HCV	Hepatitis C Virus
HIV	Human Immunodeficiency Virus
HPC	High Performance Computing
IEA	International Energy Agency
IGF	Insulin Growth Factor
ILZRO	International Lead Zinc Research Organisation
IMP	Integrated Manufactured Products
IP	Intellectual Property
IPCC	Inter-Governmental Panel on Climate Change
IT	Information Technology
IT&T	Information Technology and Telecommunications
IWS	International Wool Secretariat
KBD	Knowledge-Based Deliverable
LAN	Local Area Network
MCA	Minerals Council of Australia
MDP	Multi-Divisional Program
MIA	Murrumbidgee Irrigation Area
MNRF	Major National Research Facility
MP&MP	Mineral Processing and Metal Production
MRC	Meat Research Council
NATA	National Association of Testing Authorities
NH&MRC	National Health and Medical Research Council
NML	National Measurement Laboratory
NORMET	North American Metrology Cooperation
NRMA	National Roads and Motorists Association
NSC	National Standards Commission
PAC	Pacific Accreditation Cooperation
PASC	Pacific Area Standards Congress
PCS	Personal Communication Service
PI	Performance Indicator
QDPI	Queensland Department of Primary Industry
R&D	Research and Development
RACV	Royal Automobile Club of Victoria
RDC	Research and Development Corporation
RDN	Research Data Network CRC
RFA	Regional Forest Agreement
RIRF	Rural Industries Research Fund
ROI	Return on Investment
RSV	Respiratory Syncytia Virus
RTA	Roads and Traffic Authority
RV	Research Vessel
SAA	Standards Association of Australia
SAC	Sector Advisory Committee
SERDF	State Energy Research and Development Fund (New South Wales)
SME	Small to Medium Enterprise
TBD	Technology-Based Deliverable
TSRA	Torres Strait Regional Authority
UN	United Nations
VLBI	Very Large Baseline Interferometry
VSOP	VLBI Space Observatory Project
WAN	Wide Area Network
WEC	World Energy Council

Field Crops

Sector Foreword

The Field Crops Sector Advisory Committee identified significant opportunities for increased consumption and trade of the crops and commodities covered by this Sector resulting in benefits to the rural communities and to the economic well-being of Australia.

The Committee is conscious that research from CSIRO has brought about major quality and productivity gains in our Sector in recent years; increased cotton production, the introduction of new feed wheats, improved grain storage techniques and improved nitrogen management in the sugar industry are examples. We are impressed by the balanced mix of longer term strategic research and shorter term tactical work in the Sector.

The Committee endorses the focus of the Sector Plan on three key areas:

- the application of novel gene technologies to increase the number of quality products
- the development of effective management tools to optimise agricultural inputs
- the development of systems to maintain resource security both in terms of sustainable production and the development of a clean and green market image.

At the same time, it is critical that potential growth areas requiring a significant research component be identified ten or more years in advance to enable CSIRO to adequately position itself to address those needs. This is particularly true of the new gene technologies which have already begun to revolutionise agricultural production worldwide. CSIRO has the pre-eminent role in gene technology research for Australian agriculture, a role that is crucial in developing the product differentiation needed to meet exacting market needs.

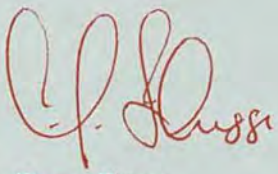
Research aimed at developing crops with quality characteristics suitable for value-adding to targeted markets in Asia is of major importance for the Sector. Research into product development needs to be increased while not jeopardising the effort in productivity research. We see this as an ideal area for an increased investment in this Sector, and should be developed with close links to the Food Processing Sector.

Linkages to other Sectors also need to be strengthened, in recognition of the importance of pastures in the total farming system (Wool and Textiles; Meat, Dairy and Aquaculture) and the need to preserve our soil, water and biodiversity resources (Biodiversity; Land and Water).

The Committee felt strongly that more effort should be concentrated on effective technology transfer, particularly by further developing linkages with other agencies.

The Sector should also have, as a priority, a well-planned education program designed to introduce to the public the benefits of new gene technologies.

Overall, the Committee felt that research carried out in this Sector will produce large and widespread benefits to Australia. The opportunities created by trade liberalisation policies combined with the great potential of emerging gene and information technologies, can secure Australia's position as a world leader in the production of basic foodstuffs. Penetration of the Asian market with high quality, value-added products, underpinned by innovative research, will provide much of the future prosperity of the rural sector in Australia.



Trevor Flügge
Chair, Field Crops Sector Advisory Committee

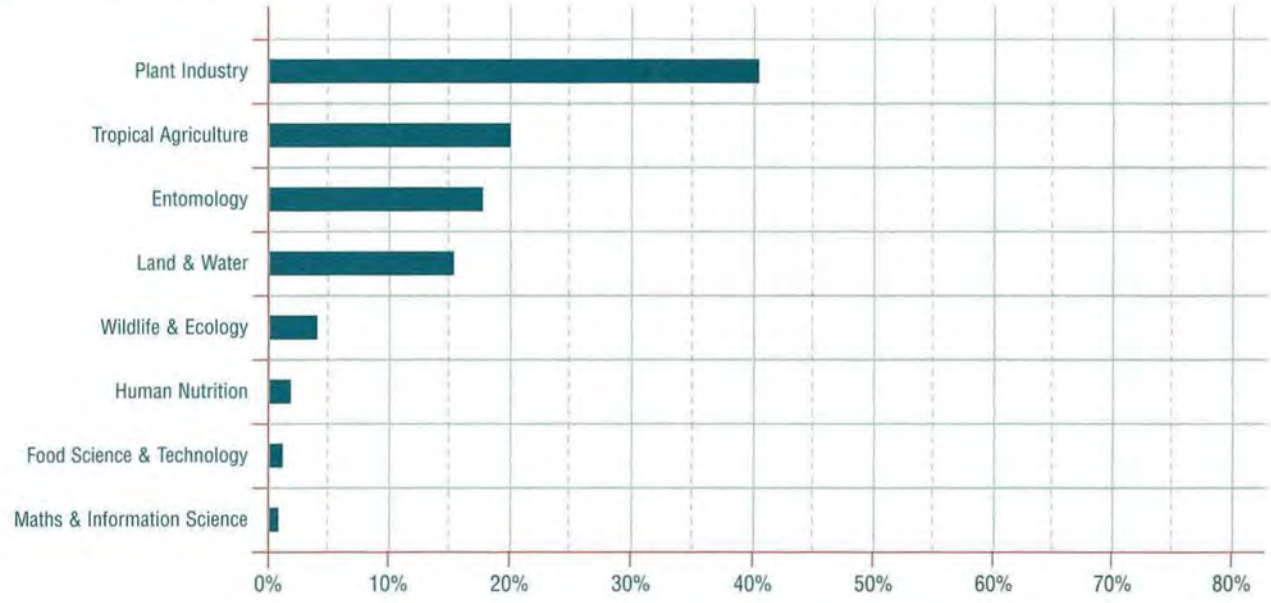
Field Crops Sector Advisory Committee:

Trevor Flügge (Chair), Australian Wheat Board; *Harry Bonanno*, Australian Cane Growers Council Ltd; *Tony Gregson*, Grains R&D Corporation; *John Grellman*, Cotton Seed Distributors Ltd; *Richard Haire*, Queensland Cotton; *Mike Hedditch*, Rice Growers Association of Australia; *Chris Henderson*, Farmer; *Chris Hudson*, Goodman Fielder Ltd; *John Lovett*, Grains R&D Corporation; *Don Marshall*, University of Sydney; *Baillieu Myer*, Myer Foundation

Field Crops

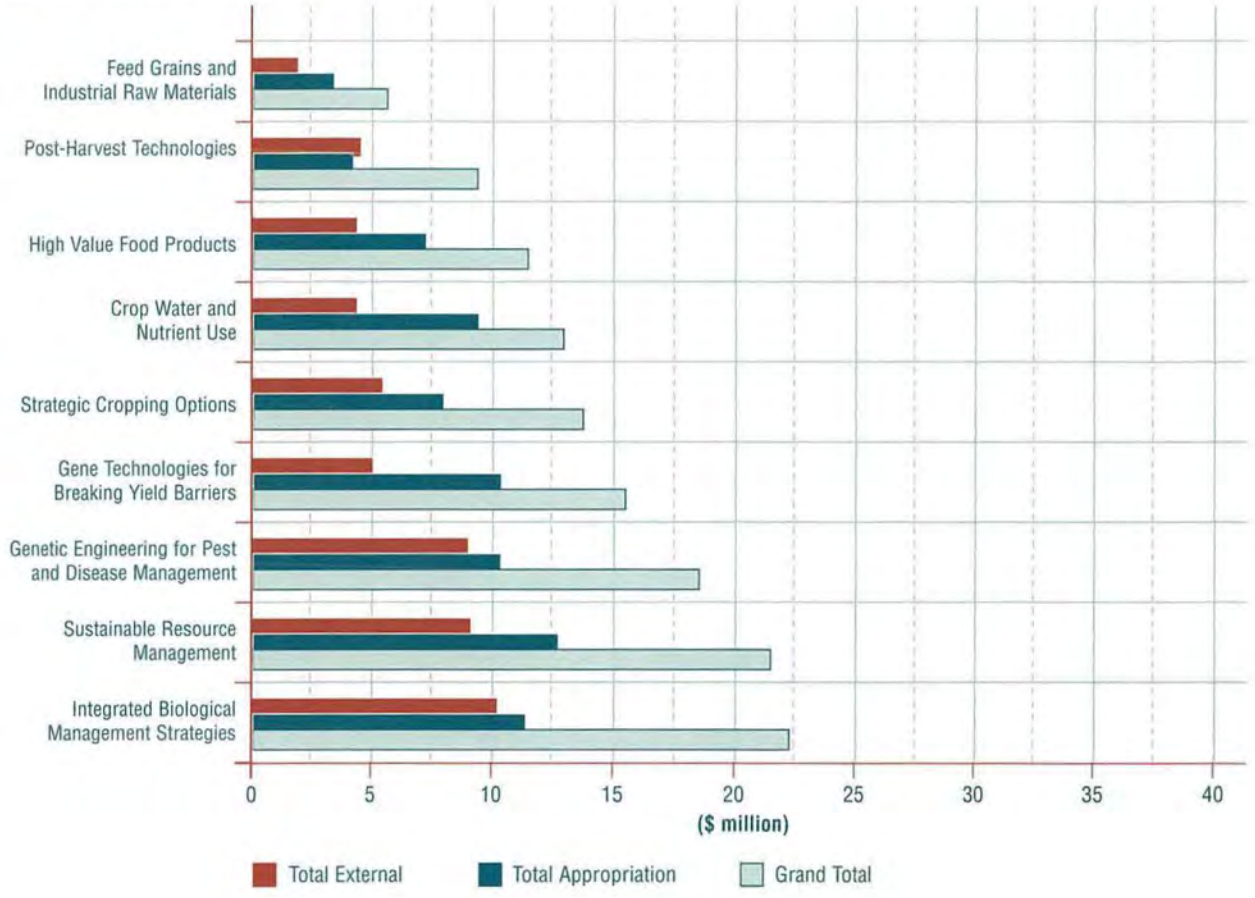
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $130.58 million)



Triennial Investment by Component

(Total Sector Investment $130.58 million)



Mission

To assist industry to achieve 20% growth by the year 2000, to increase exports into Asian markets, and to increase domestic value added to the harvested product by our processing industries. This has to be achieved with an increased emphasis and capability for maintaining the critical soil and water resource bases along with conservation of the associated biodiversity resource.

Overview

Major issues

The cropping sector is part of a total agribusiness enterprise in Australia that generates in excess of $22 billion per annum worth of primary products and $37 billion turnover annually in the food and beverage manufacturing industries. CSIRO has the R&D and industry infrastructure and linkages to contribute to the need to double world food production over the next 30 years. It is an opportunity for growth that should not be mismanaged.

Much of the demand will arise from the expanding affluent middle classes in the rapidly developing economies of South-East Asia. Australia is well placed to capture an increasing share of these markets, particularly with their changing dietary preferences for crops and crop products of which Australia has traditionally been a major producer and exporter.

ABARE analyses of recent APEC developments have predicted that Australia will be a major net beneficiary from trade liberalisation, with over half of the benefit arising from the inclusion of agricultural products. This liberalisation will initially be between the more developed countries that will be looking principally for quality-related traits in food products, and for consistency of supply.

Increased exports and import replacement will enhance Australia's already highly favourable balance of trade in food products.

Priorities

CSIRO must give increasing attention to product diversity and differentiation for emerging markets, and to product development and value-adding potential. It must also aim for reliability of supply, and achieve critical mass production of quality products for overseas markets. Australia's geographic and climatic diversity provides some buffer against localised production failures, but there is a need to diversify the range of production environments for the highest value crops, and to develop more flexible portfolios for the opportunity cropping necessary to meet fluctuating market demands.

Intellectual property development will be increasingly important in the Field Crops Sector, both to establish Australia's opportunities for market control and to lever advantage in bargaining for the use of overseas-owned proprietary technologies.

Australia's Asian markets are noted for being health conscious, a trend that is now evident in many Western nations. Health potential of foods will be a major driver of markets, along with cleanliness and the maintenance of product quality, reduced reliance on chemicals, and value-adding product development. CSIRO's research will focus around these key drivers.

The downturn in the animal production enterprises in the high-rainfall pastoral zones provides the need and creates a major new opportunity for increased cropping in these climatically advantaged regions.

Many of Australia's competitors with intensive agricultural systems are faced with major environmental contamination problems. Australia has an opportunity to capitalise on its relatively clean and green market image which relies on low levels of chemical residues in crop products, and a perception that they are grown in environmentally sustainable production systems.

CSIRO's farm management research effort will be linked to that of the Land and Water and Biodiversity Sectors, and to the Food Processing Sector for value-added product development.

Research strategies

CSIRO's short-term strategy is to build upon recent advances and development of capabilities in gene and information technologies to meet the opportunities and challenges faced by the sector.

Advanced gene technologies now enable production of new cultivars with reduced time lag, by adding new characters to otherwise high-performing cultivars. Research will be directed to development of cultivars tailored for increasingly discriminating markets.

With the new capabilities now opened up in its research, CSIRO is aiming to modify starch and protein properties in wheat to increase the differentiation in this major grain product of Australia. New product goals are found in barley, canola, cotton and sugar.

Some of Australia's key crops are currently facing static yields. Physiology, biochemistry and gene technologies are being brought together to overcome these barriers.

CSIRO will aim to reduce the chemical burden on the environment, and the risk of contamination of crops

and crop products, through genetic strategies based on natural and synthetic resistance genes, and new management practices utilising optimised resistance gene deployment, biological control agents, crop and pasture rotations, decision support systems and natural biofumigant compounds.

Water is most often the major factor limiting crop production in Australia, with consequent effects on nutrient uptake and yield. In irrigation systems, inappropriate practices can lead to major environmental degradation. CSIRO will use both genetic and management approaches to improve crop water-use efficiency, nutrient uptake and utilisation, and minimisation of water wastage.

CSIRO will catalyse the development of cropping options and flexible crop-pasture systems, particularly for the high rainfall zones that have been neglected for the past 30 years, and where high value opportunity cropping will be possible.

Improved adoption of management technologies will have an immediate impact on profitability. The sector advisory committee has endorsed the CSIRO Executive's concerns about the transfer of research results. CSIRO will reinforce its efforts to build on Australia's established track record in development of farm management and post-harvest technologies, using all appropriate means of technology transfer, including Internet-based decision support systems.

All the organisation's project planning will include technology transfer objectives. CSIRO is actively developing its links with Commonwealth and State government departments and agencies, universities and companies in the agribusiness system, and with a number of Cooperative Research Centres, specifically to enhance technology transfer.

Outline of external consultations

The CSIRO Field Crops Sector is guided by the broad representation on its advisory committee of producers, processors and marketers. Its collaborative research with Commonwealth and State government departments and agencies and universities is enhanced through consultation with rural industry research corporations, industry groups and companies either sponsoring, or benefiting from, its work in the sector.

The emphasis is on collaborative R&D with joint management teams involving CSIRO's committed partners.

Scientists in the sector are members of technical advisory boards of companies, lead CRC programs, and are active on editorial boards of scientific journals. Extensive links and networks with other research institutions, both in Australia and internationally, enhance the development of new knowledge and provide scientific and performance benchmarks.

Major objectives and key potential outcomes

CSIRO's major objectives are to enhance export potential through development of high value plant products and to develop appropriate technologies for their management in sustainable production systems.

> *CSIRO's key potential outcomes will be increased profitability for producers, marketers and processors, an increased range of differentiated quality plant products, and reduced chemical usage in production and post-harvest systems.*

The development of foods that promote human health is a rapidly emerging international trend. A key element of this development is plant-based products containing key nutrients. This work has prompted closer cooperation with the Food Processing sector.

There is a long-term need to move away from overuse of non-renewable petrochemical sources of industrial raw materials and to reduce the environmental impact of some of the industrial processing associated with food production. These needs are now being addressed through rational redesign of plant materials that can reduce or remove the processing requirement.

Australia has, in the main, a low-input agriculture. Further irrigation potential is restricted. Productivity and profitability gains must come from better knowledge of what is limiting yield and quality in dryland crops, and improvement of cropping potential in the higher rainfall zones.

Inefficient use of water and nutrients, particularly nitrogen, is the direct cause of major soil and water degradation problems. Turning waste into crop dry matter and protein will benefit productivity and reduce degradation.

> *CSIRO's research will develop agricultural management practices that conserve resource use, reduce off-site impacts and manage land within its capability. This will be done in a context of increasing farm profitability, allowing funds to be spent on maintaining and reclaiming the resource base, thus enhancing sustainability.*

Three recent developments will provide novel and revolutionary pest and disease management strategies into

the 21st century. The first, which underpins the new strategies, is the rapid improvement in technologies for the transformation of crop plants. The second is the ability to clone and modify naturally occurring plant resistance genes. The third is the prospect of developing completely novel forms of resistance for pest management.

Management strategies will integrate the rational use of pesticides with biological control and the deployment of transgenic plants and biopesticides. They will build upon a knowledge of the biology of the pest, weed or disease in the cropping system.

There is substantial potential for yield increases through development of appropriate harvesting strategies combined with post-harvest conditioning. In the post-harvest area—both on-farm and in bulk handling systems—CSIRO's research seeks to enhance the quality of Australian grain and grain-based products, through storage technologies that deliver products free of residues and without loss from pest damage. New grain varieties with specific end-use characteristics will have particular storage and handling requirements.

Customers, technology transfer and commercialisation

The direct users of improved cultivars and management practices are primary producers, whose interests are represented by the Rural Industry Research and Development Corporations.

In the development of new cultivars, CSIRO works together with public plant breeding programs and seed companies as commercial partners.

Advisory services, and particularly private consultants, are increasingly being called upon to integrate the complex requirements of more intensive agricultural production systems. CSIRO expects these to be key agents in delivering the benefits of its research.

For resource security, CSIRO's clients are State and Federal government bodies, water authorities, regional irrigation management boards, and land and water management planning groups.

Other important clients are bulk handling and marketing authorities and, increasingly, food processing companies supporting pre-farm gate research.

Technology transfer—commercialisation strategy—management of intellectual property

No longer does CSIRO passively hand over the results of its research to State departments and public breeding programs. Business plans provide for the delivery of final product, both with public and private partners.

Early entry of commercial partners into collaborative programs increases the chances of commercial success.

In recognition of the crucial importance of adopting management strategies for new and improved crops, including guidelines for environmental quality and sustainability, CSIRO is increasing its emphasis on incorporating management strategies into simulation models and decision support systems.

The development and management of intellectual property are key components in realising the commercial potential of research in product development. Over the past 10 years CSIRO has gained experience in business management, commercialisation strategies, and protection of its intellectual property through patenting and licensing.

Marketing and communication

Marketing

The ultimate responsibility for marketing of products arising from CSIRO's research lies with its partners, both public and private. Rather than taking risk equity positions in the market place, CSIRO seeks licence and royalty positions to reduce its exposure to commercial risk and potential litigation.

The advisory committee will work with the sector to enhance the marketing of CSIRO's research capabilities.

Communication

Where CSIRO has commercial partnerships, it will work jointly to promote the products of its research. This will involve training advisers, consultants and technicians in industry; media releases on major achievements during development of products; major briefings on release of products; and information/publicity events such as field days and seminars to growers and agribusiness.

CSIRO recognises the importance of increased political and public appreciation of the key role that its gene technology research has for trade and manufacturing industries. It is working closely with the Australian Food Council and the Australia and New Zealand Food Authority.

Development of CSIRO's R&D capacity

CSIRO will enhance its existing skills by increasing the cooperation already evident among the divisions in this

sector. The organisation is building the new research teams needed in areas such as the quality attributes of starch and protein in cereals, carbohydrate and fatty acid metabolism and manipulation, and the introduction of social science in technology transfer.

Market awareness of the value of health-related features in crop and crop products, and the identification of crop products of potential value as industrial feedstocks, will lead to new quality traits as targets for plant improvement.

CSIRO's research delivery will be achieved with the development of new tools and strategies for technology transfer.

CSIRO's skills and expertise in gene technologies need to be developed further to seize the opportunities for precision engineering of crop plant species to give improved quality and productivity; pest and disease resistance, increased efficiency of water and nutrient use and environmental sustainability.

Improved understanding of pest ecology will be necessary to develop innovative biological control strategies for management of vertebrate and insect pests.

There are opportunities to apply information technology to a variety of agricultural objectives, including integrated pest management, simulation modelling and decision support systems to manage resource use efficiency both in irrigated and dryland systems.

A range of cross-discipline skills are needed to address problems of production, management, environmental aspects of production systems, and post-harvest storage and transport.

To take adequate account of the human element in farming systems operations and decisions, CSIRO needs in some instances to have access to capabilities in the social sciences, either in-house or through links with other organisations.

CSIRO also has a responsibility to assist with the continuing training of farm advisers and consultants, and to provide technical expertise in the value-adding components of the agribusiness system.

Performance and evaluation measures

The success of CSIRO's R&D effort will be measured initially by its identifying scientific opportunities and exploiting them, by its products and their adoption, and by attracting external funding.

Consequent measures will demonstrate increased farm profitability, enhanced trade performance, employment gains, and stability of the resource base, including biological diversity.

Success will also be measured through development of enabling technologies, maintenance of Australia's international profile, and attracting Australian-owned intellectual property.

Relevant CSIRO performance indicators are: external earnings (PI2); adoption and impact of research (PI3); customer satisfaction (PI4); publications, reports and patents (PI5); and student training (PI6).

Sector coordinator

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CSIRO Plant Industry
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Canberra ACT 2601
Tel. (02) 6246 5250, fax (02) 6246 5530
email: Jim.Peacock@pi.csiro.au

Divisional and other participation

Plant Industry (89.4 EFT); Entomology (35.5 EFT); Tropical Agriculture (32.0 EFT); Land and Water (26.2 EFT); Wildlife and Ecology (6.3 EFT); Human Nutrition (5.8 EFT); Food Science and Technology (4.0 EFT); Mathematical and Information Sciences (1.6 EFT); with substantial inputs from the Cooperative Research Centres for Plant Science, Sustainable Cotton Production, Legumes in Mediterranean Agriculture, Biological Control of Vertebrate Pest Populations, Tropical Plant Pathology, Soils, Weeds Management, Sustainable Sugar Production, and Catchment Hydrology; the proposed CRCs for Sustainable Rice Production and Northern Grains Production; and the Agricultural Production Systems Research Unit (APSRU).

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	25.0	26.1	26.6
External funding	16.5	17.5	18.7
TOTAL	**41.5**	**43.6**	**45.3**
External/total ratio	40%	40%	41%

Food Processing

Sector Foreword

I have pleasure in submitting the Foreword to the Food Processing Sector's plan for the next Triennium. The Sector Advisory Committee believes that we will be able to play an increasingly important role in providing direction and feedback to CSIRO as time goes by. Our members are enthusiastic for the task but have been on a steep learning curve during our first few months of operation. As we achieve a deeper understanding of the activities of the Divisions, we are confident we will be able to use our diverse experience to add value to CSIRO's operations.

The Committee considered the draft plan over a number of meetings, commencing in September. Modifications have been made to the various component research plans following comments by our members, but the Committee has taken the view that changes in direction or emphasis under CSIRO's new sectoral structure can evolve fairly gradually. The major Divisions in the Sector have already undertaken reviews of their research priorities in recent times to ensure their operations are orientated to provide the greatest benefits for industry and the community, so the changes sought by the Committee were generally limited to modest changes of emphasis.

I would like to draw your attention to one issue we discussed. It is very important that CSIRO concentrates on activities that will benefit its external stakeholders, but the Organisation must be careful not to place too much emphasis on providing short term revenue earning fixes for individual companies. Our industry looks to CSIRO as a national resource with the responsibility of undertaking long term strategic research (including "public good" work) as well as contributing to shorter term needs. Thus the Committee viewed with some concern CSIRO's recent request for the Sector to increase its external earnings to 45%. This will increase the pressure on research staff to seek short term testing and consultancy work, which arguably already constitutes too great a proportion of their efforts. The Division of Food Science and Technology's work on oxygen scavenging packaging is an excellent example of the benefits that can accrue to industry from CSIRO undertaking early work on research projects before a specific customer is sufficiently interested to make a final commitment.

Unless the rural research and development corporations can be persuaded to increase their contributions to cover a higher percentage of the real costs of doing research, it will be difficult for the Divisions to achieve the tactical/strategic balance sought by the Sector Advisory Committee if they must also increase their external funding percentage.

Yours sincerely,

W. Murray Rogers
Chair, Food Processing Sector Advisory Committee

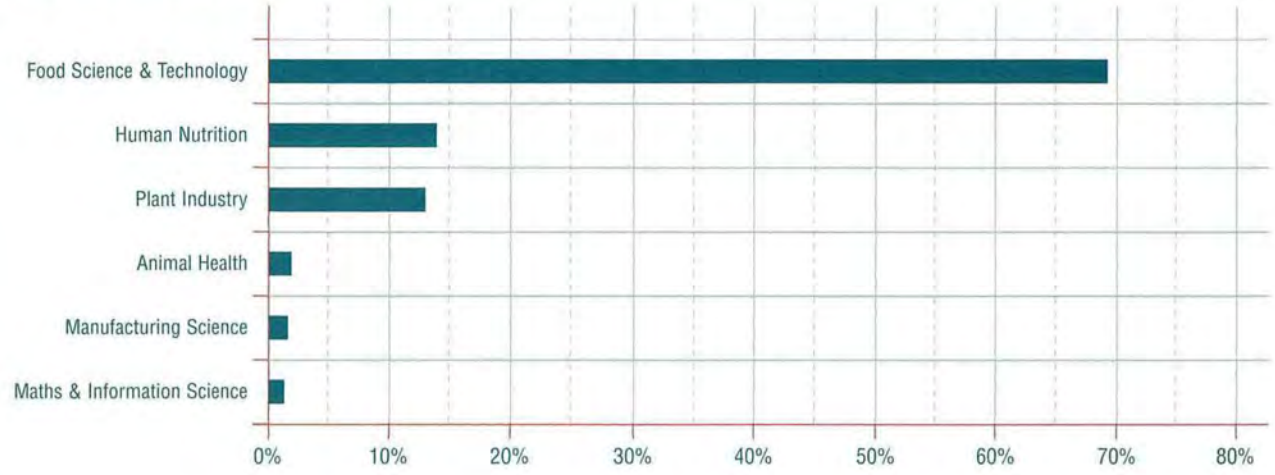
Food Processing Sector Advisory Committee:

Murray Rogers (Chair until June 1997), Kellogg (Aust) Pty Ltd; *Simon Brooke-Taylor*, National Food Authority; *Ken Buckle*, University of NSW; *Bryan Cox*, Goodman Fielder Ingredients Ltd; *Paul Donnelly*, Dairy R&D Corporation; *Roger MacBean*, QUF Industries Ltd; *Hans Sidler*, Woolworths Supermarkets; *Robert Young*, Unifoods; *Peter Wallace*, National Heart Foundation; *Peter White*, Qld Dept of Primary Industry

Food Processing

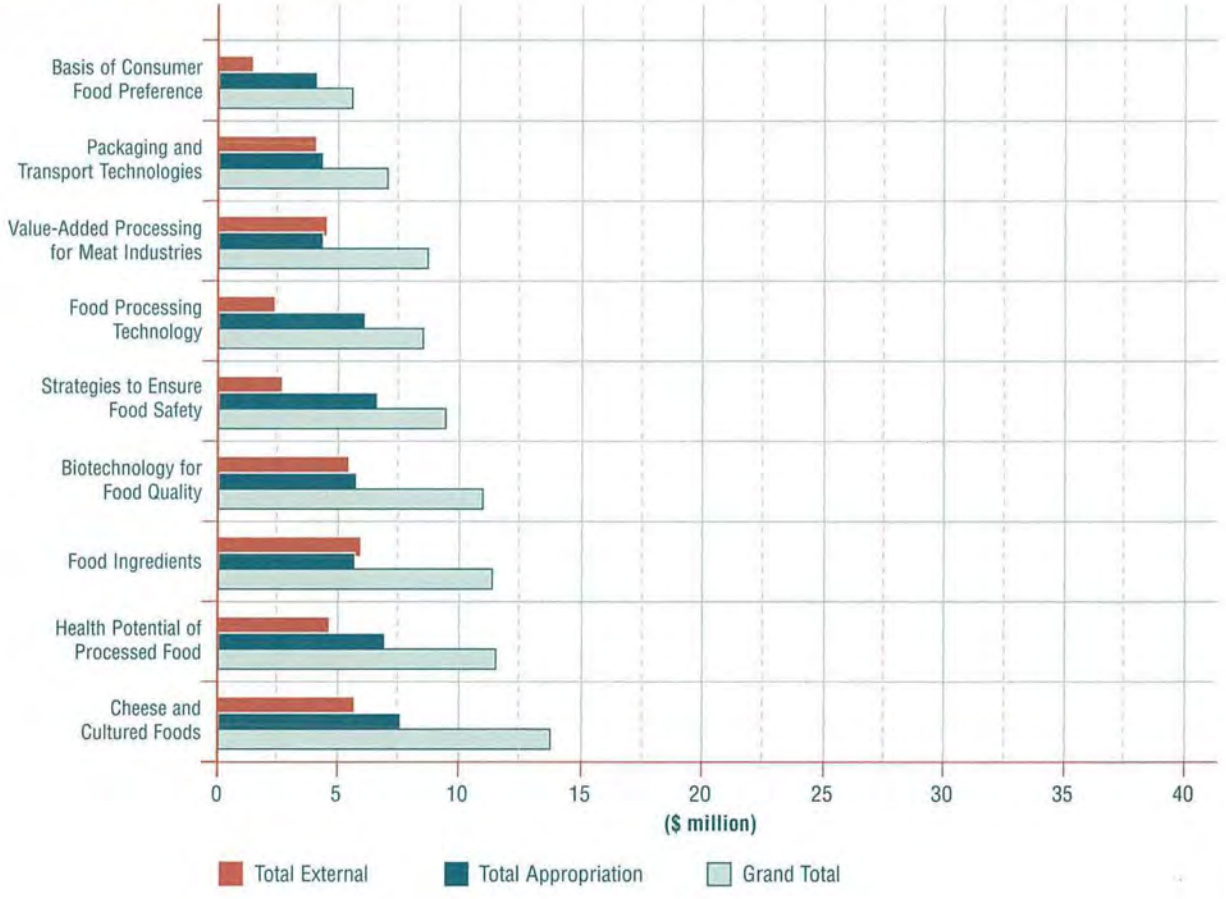
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $85.71 million)



Triennial Investment by Component

(Total Sector Investment $85.71 million)



Food Processing

Mission

To provide research and development expertise to enhance and sustain the competitiveness of the Australian food processing industry and provide objective scientific advice on food safety and nutrition for the community and industry.

Overview

Major issues

Export development, globalisation, economies of scale and some key customer requirements and perceptions (such as innovation, quality, safety, health and lifestyle) are shaping the industry technologically. Opportunities and challenges are set out in the following points:

- The industry is focusing on adding greater value to products manufactured in Australia and selling them to a global market. Australia is well placed to capitalise on growth in the Asia/Pacific region (33% of world GDP by 2010), acting as a bridge for Western participation and a base for export.
- Global businesses move investments to sites with the greatest competitive advantage. Australia must address issues that have hampered competitiveness, including production costs, innovation and the fragmented infrastructure of food science and technology.
- The trend towards world-wide integration and fewer, larger food companies, predominantly based outside Australia. Processing and distribution are increasingly concentrated.
- A powerful and highly concentrated domestic retail industry, with increasing growth of house brands in some food categories.
- Growing importance of food service, and integration of processing/service sectors.
- Shifts in demographic and social factors (such as the age and ethnic profiles of our society, the reduction in consumer cooking skills or interest associated with the widespread use of convenience foods).
- Changes in consumer demands and in regulations relating to food safety, health claims and environmental concerns.
- Emphasis on food safety, arising in part from major outbreaks of food-borne disease.
- Greater consumer awareness of the impact of diet on health.
- Marketing based on 'clean and green' perceptions of our production environment.

Potential value to Australia

The food processing industry accounts for about a quarter of manufacturing jobs in Australia and is our biggest earner of income from manufactured exports. It is growing strongly, despite a mature domestic market. Growth has been primarily through exports. It is predicted that the share of production for export will continue to increase.

CSIRO makes a unique contribution in the sector, accounting for most of the public R&D expenditure. CSIRO is the only agency that applies very broad multi-disciplinary skills to food processing. CSIRO's national infrastructure provides expertise across the entire industry supply chain, seen as a major advantage by the industry. CSIRO contributes to the infrastructure that enables the global companies which dominate the industry to use Australia as an export base.

CSIRO maintains a strong body of expertise as a national resource, particularly in safety and nutrition. Crises may arise rapidly and have a dramatic impact on the industry. CSIRO has played a pivotal role in the response to such emergencies and will continue to mobilise resources as needs arise.

Broad strategies

CSIRO will emphasise support for export development, particularly in Asia. Ten of Australia's largest 14 export markets are in Asia. Considerable Asian market growth has been in high value-added, highly processed products.

When setting research priorities, CSIRO will consider barriers to exports that are responsive to R&D. CSIRO will continue initiatives related specifically to Asia. A CSIRO commercial manager located in the office of a Japanese trading company in Tokyo will facilitate relationships between Australian and Asian companies, based on commercialisation of CSIRO technology. The CSIRO 'Food into Asia' program will support research in partnership with companies targeting Asia.

CSIRO will use the new organisational structure to respond to the industry's desire for stronger links across the supply chain. CSIRO will integrate domain-specific capabilities (Divisions of Food Science and Technology and Human Nutrition) with generic manufacturing expertise (e.g. CSIRO Mathematical and Information Sciences) and expertise in raw material production (e.g. Division of Plant Industry).

The industry has expressed a view that there is a need to increase the proportion of resources allocated to longer-term strategic research to meet future needs. The strategic research base will be strengthened by keener

pricing of research close to the market, so that more appropriation funds can be invested in strategic research.

External consultations

This plan has been compiled in consultation with the Food Processing Sector Advisory Committee, which includes senior members of the industry and other stakeholders.

The Component Research Plans (CRPs) reflect the structure of the industry and cover the industry supply chain. The sector plan is based on evolution of the existing portfolio. CSIRO has consulted extensively with industry and other stakeholders in the last two years and re-directed resources to high priority areas. This has improved the alignment of research with customer and community needs, but the range of activities may remain too diverse. The Committee will evaluate the strategies and priorities of industry and government and advise further on an appropriate focus for CSIRO's activity.

The creation of the Australian Food Council as the peak industry body has generated a new focus on industry issues. CSIRO will develop these processes in consultation with the Council.

Major objectives and key potential outcomes

Objective 1

To support the industry's focus on international competitiveness and export development. Imperatives include product and process innovation, cost-effectiveness, product quality and differentiation, packaging and transport, food safety, market intelligence.

The research portfolio will be balanced with regard to the spread of activities across the industry supply chain and industry segments, the competitive impact and maturity of technologies, probability of success, and maintenance of a relevant and sustainable skills base. The effort will be focused on niches in which CSIRO can make a significant difference to competitiveness.

CSIRO will avoid areas addressed adequately by other agencies, e.g. seafood technology. Product development is better performed directly by companies and will not be a primary focus, although in some cases it will flow naturally from other activities.

Outcomes will include:

- Field crops that have been manipulated to provide raw materials with improved characteristics for processing, particularly to provide enhanced quality of finished products.
- Food ingredients with enhanced functionality, quality, cost-effectiveness, and health benefits, and which create opportunities for innovation in finished products.
- Technology that will enable processors to manufacture products of consistently high quality, by transforming raw materials of variable quality in a cost-effective manner. Process optimisation and control systems, automation, best-practice protocols and improved unit processes will be emphasised, with a focus on cheese making, extrusion and meat processing.
- Meat processing technologies that add value by enhancing consumer appeal and increasing the utilisation of the entire animal.
- Novel food products that meet consumer requirements for convenience, freshness and perceived health benefits.
- Active packaging technologies and improved transport protocols that will allow Australian products to reach distant markets in good condition at competitive cost, create opportunities for new markets and products, and improve economies of scale.
- Understanding of issues determining consumer preferences, including nutritional, sensory and cultural considerations in local and international markets.

Objective 2

To meet the needs of stakeholders (government, community, industry) for research and expertise in nutrition and food safety.

CSIRO will continue to play an important role in setting national and international agendas in the public good areas of food safety and nutrition. The viability of the industry depends increasingly on its capacity to demonstrate that it is supplying safe, wholesome products. CSIRO capability is pre-eminent in this area.

Outcomes will include:

- Methods for detecting and controlling hazardous microorganisms, microbial toxins, and toxicants of plant origin across the food chain. Emphasis will be placed on emerging hazards and those with the greatest actual or potential impact in the community.
- Knowledge to underpin objective scientific advice to stakeholders on nutritional and food safety matters, including scientific input to development of government policy.

Objective 3

To use CSIRO's national multi-disciplinary capabilities to enhance links between R&D agencies and across the industry supply chain.

Australia's infrastructure for food R&D is fragmented. Many Australian research groups lack the critical mass and the access to expertise across the innovation process that is required to provide internationally competitive outcomes. CSIRO will use its national structure to facilitate reduced fragmentation, through cooperative alliances with other agencies. A joint venture is being developed with the Australian Food Industry Science Centre (AFISC). This plan has not taken account of changes that might flow from that joint venture.

Outcomes will include:

- Reduced fragmentation of publicly-funded R&D for the food industry.
- Greater cooperation, collaboration and complementarity between research agencies.
- Appropriate interfaces with providers of technical services to the sector.

Customers, technology transfer, marketing and communication

Anticipated customers

Development of CSIRO's customer base will focus on long-term relationships with rural industry research and development corporations (RIRDCs) and large companies. Many RIRDCs (particularly meat, dairy and grains) will remain important customers. Efforts will be made to improve links with some RIRDCs through formal strategic alliances. The prospect that RIRDCs will reduce their involvement in off-farm research during the next few years is likely to lead to more involvement by individual companies in research.

In the corporate sector, the emphasis will be on larger companies that are able to make an appropriate financial commitment to research projects and that can implement the outcomes of research. These will include large Australian and international corporations and many medium-sized companies. Smaller companies will continue to be served mainly through provision of advice and short-term contracts for technical services.

CSIRO will participate in Cooperative Research Centres where they complement its activities and are relevant to its mission in the sector, when financial arrangements are appropriate, and when there are no commercial conflicts.

Some CSIRO activities, primarily in food safety and nutrition, are for the 'public good' and thus have no single customer. In these areas CSIRO provides advice to industry as a whole, as well as to the community; it also contributes to development of government policy, e.g. through the Australia New Zealand Food Authority.

Technology transfer–commercialisation–IP management

Foreign ownership in the industry is substantial, but should not be an impediment to Australia's ability to capture the benefits of R&D, if R&D agreements and intellectual property management arrangements are structured appropriately.

Close relationships with customers ensure that projects are relevant to industry needs. Commercialisation strategies flow naturally from CSIRO's relationships with its customers. RIRDCs active in the sector are set up for commercialisation, and CSIRO is working with them to enhance transfer to industry. Research agreements will include a provision in the research plan for effective technology transfer. Where it is appropriate commercially, in these and other areas, research results will be published in the scientific literature

Technology transfer in nutrition and food safety will often be in partnership with other agencies, through mandatory or voluntary codes or standards, government policy, and community education.

Marketing

Participating divisions will market their research, with strategy development and coordination on a sectoral basis. Market research now in progress will help to determine the most useful strategies. CSIRO anticipates further development of the embryonic 'Industry Contact Manager' program, in which its senior staff liaise closely with major present and potential customers.

Development of CSIRO's R&D capacity

There will be a greater emphasis on more effective use of the skills base possessed by CSIRO and its collaborators. Further integration of research across the food chain is essential in this sector, where inputs at the production level can significantly affect the finished product. Opportunities will also be pursued for integration of skills across disciplines, both within CSIRO and through collaboration with other complementary agencies.

CSIRO has capability in most major science and engineering disciplines related to food processing and packaging. The Component Research Plans (CRPs)

identify various areas in which enhancement of specific skills will take place to achieve planned outcomes.

CSIRO has extensive pilot plant facilities, particularly for dairy and meat processing, extrusion, packaging and plant cell culture. However, the need for infrastructure improvement is pressing: some buildings and equipment, particularly pilot plants, do not meet modern standards. Collaboration with other agencies, notably a joint venture with AFISC, will partly relieve this problem. CSIRO also plans to redevelop facilities in Sydney and Brisbane, the latter in cooperation with complementary Queensland agencies.

Examples of R&D capacity development noted in CRPs include:

- Capture of intellectual property in the form of novel genes/promoters and genetic manipulation technologies.
- Studies of macromolecular interactions and aggregation processes as a basis for control of food texture and ingredient functionality.
- Development of non-dairy ingredients, where a gap analysis identifies areas in which R&D may enable exports or import replacement.
- Development of generic process-control strategies.
- Studies of the molecular basis for variation and virulence among foodborne microorganisms.

Performance and evaluation measures

The Sector Advisory Committee will develop specific performance measures in the first year of the triennium, in the light of CSIRO's corporate performance indicators. The performance and evaluation measures relate to CSIRO's mission for the sector. They will assess CSIRO's impact on the food industry competitiveness in terms of the rate of development of enabling technologies, the level of adoption of research outcomes and the consequences of research, demonstrated by novel products or processes and trade performance. Public good elements will be assessed in terms of CSIRO's profile and influence in safety and nutrition issues.

Divisions will be held accountable for outcomes identified in CRPs. The research projects will be managed using appropriate techniques, including 'MANAGE'.

Significant external collaborators

AFISC; Australian Meat Technology; CRCs-International Food Manufacture and Packaging Science, Industrial Plant Biopolymers, Plant Science, Quality Wheat, Meat Quality, Food Industry Innovation; Universities—Sydney, Western Sydney, Melbourne, NSW, California; Technical University of Denmark; NSW Agriculture; WA Department of Agriculture; SARDI; USDA-ARS Poisonous Plants Laboratory; CBS, Baarn, Netherlands; Health Canada.

Sector Coordinator

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Divisional participation

Food Science and Technology (127.0 EFT); Human Nutrition (27.7 EFT); Plant Industry (25.0 EFT); Manufacturing Science and Technology (2.8 EFT); Mathematical and Information Sciences (3.6 EFT); Animal Health (4.0 EFT).

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	15.6	16.3	16.8
External funding	10.7	12.3	14.0
TOTAL	**26.3**	**28.6**	**30.8**
External/total ratio	40%	42%	45%

Forestry, Wood and Paper Industries

I have pleasure in endorsing, on behalf of the Advisory Committee for Forestry, Wood and Paper Industries Sector, the Sector Plan for the next triennium to 2000.

Australia is well endowed with forest resources, in natural forests and in plantation, with a strong domestic processing industry underpinned by strategic and specific research.

However in spite of past triumphs, we have a nett trade deficit in forest products in Australia. This raises the question—can more be done to expand the sector in volume and in value to meet current and future needs of domestic and export markets?

The answers are to be found in the immediate years ahead.

They will only be developed by sound research into all aspects of the industry from sustainable resource management through efficient wood and fibre processing to new products and new and better serviced markets.

The markets will only be secured if the Sector is internationally competitive in quality and in price, and innovative in providing the types of goods and services that can flow from the natural resources of our continent.

Many growers and processors are funding specific research projects of special interest to them, and in these CSIRO acts as a commercial research provider. There are many opportunities to develop new products, based on emerging needs, individual inspiration and collective ideas. These must come from general research funding of the Sector within CSIRO.

There are substantial benefits to the Australian community of having a viable and sustainable forestry, wood and paper sector. There are strong links to regional development, agriculture, tourism and natural resource management.

The Sector Advisory Committee sees the plan as a living document to set the directions, and looks forward to further input so as to adapt, build and enhance to take the Sector to the year 2000.

Angus Pollock
Chair, Forestry, Wood and Paper Industries Sector Advisory Committee

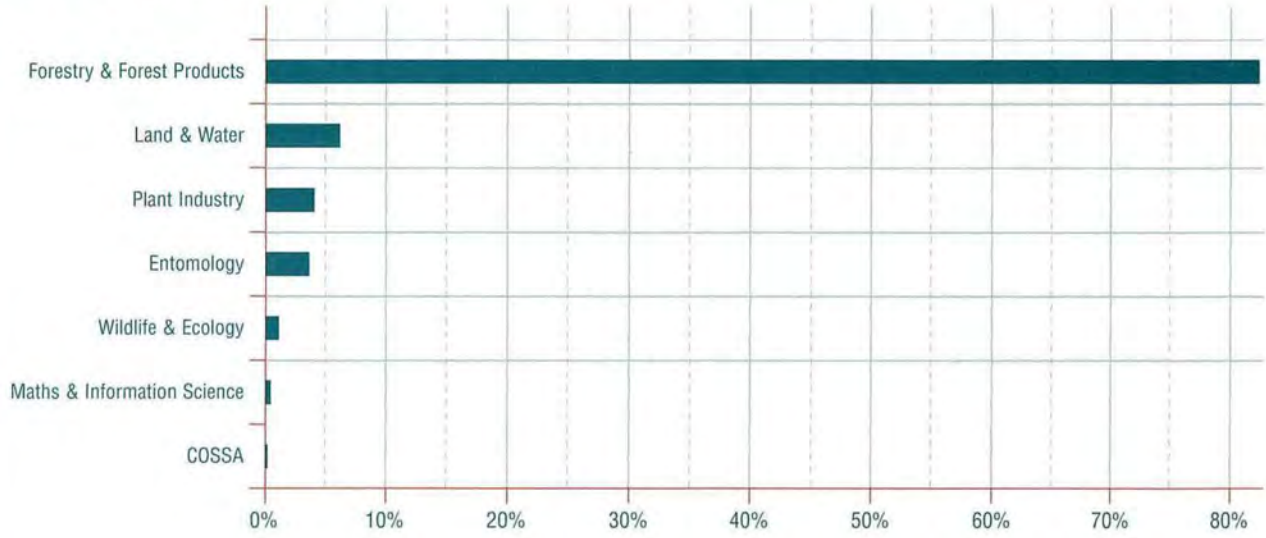
Forestry, Wood & Paper Industries Sector Advisory Committee:

Angus Pollock (Chair), Australian Paper; *Ron Adams*, Bunnings Forest Products; *Gary Bacon*, Qld Dept of Primary Industries, Fisheries & Forestry; *Ian Bevege*, Australian Centre for International Agricultural Research; *Ian Dench*, AMCOR Research & Technology Centre; *Geoff Gorrie*, Dept of Primary Industries & Energy; *Richard Rawson*, Natural Resources & Environment, Victoria; *Peter Law*, Boral Timber Industries Ltd; *Mark Thomas*, Greening Australia

Forestry, Wood and Paper Industries

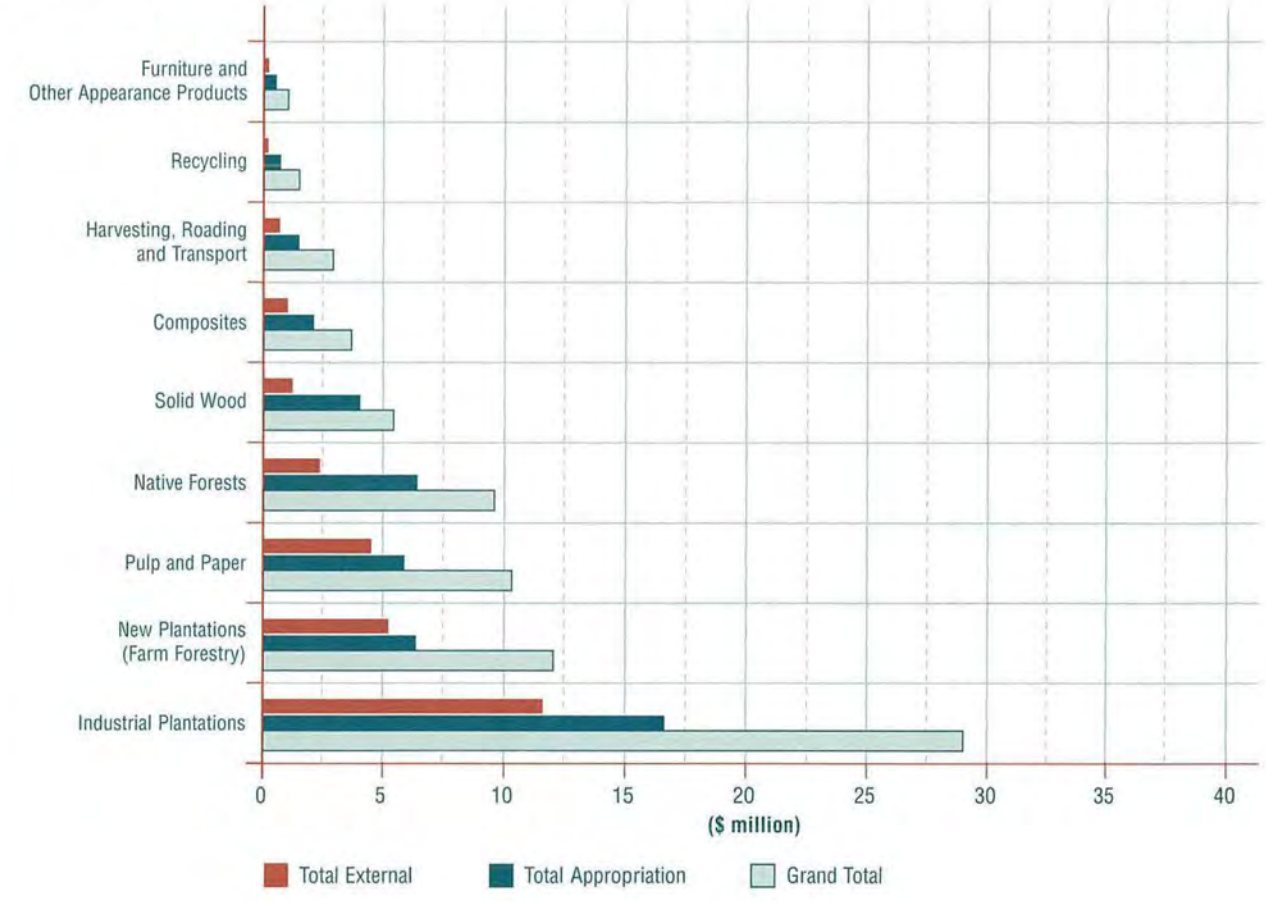
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $74.49 million)



Triennial Investment by Component

(Total Sector Investment $74.49 million)



Forestry, Wood and Paper Industries

Mission

To deliver, in consultation with our industry, government and community stakeholders, research outcomes which facilitate international competitiveness, market focus and sustainability of Australia's Forestry, Wood and Paper Industries Sector.

Overview

Over the next 20 years, research and development will underpin the global competitive performance of Australia's Forestry, Wood and Paper Industries Sector, facilitating resource development and sustainable management, improved wood and fibre performance, increased efficiency and environmental performance of wood and paper processing, and increased value-adding in wood and paper products.

CSIRO Research underpins industry growth

Research links resources, processes, products and markets

Major issues

Commercial

- **Markets:** export opportunities associated with increasing global demand for industrial wood, especially in Asia
- **Resources:** increasing supplies of plantation wood
- **Processing:** increased processing with further investment ($2 billion announced for the next 5 years)
- **Future resource opportunities:** industry-government vision to treble the nation's commercial plantations area by 2020, underpinned by market demand
- **Value adding:** opportunities for further processing of low-value resource, including wood chips.

Environmental

- Ecologically sustainable forest management
- The role of trees in improving environmental quality in agricultural areas
- The management of environmental issues in wood and paper processing
- Recycling: efficient disposal and utilisation of waste paper.

Resource development

- R&D is essential if the vision of trebling the nation's plantation area to three million ha is to be realised by 2020
- Plantations will expand on to agricultural land in lower rainfall and irrigation areas, raising new research issues in an increasingly competitive market.
- Intensive management of selected regrowth forest will also contribute to resource supply.

Sustainable management

- Australia is committed to international agreements on sustainable forest management. Fulfilling this commitment is critical to the long-term viability, social responsibilities and international competitiveness of the industry.
- Integration of trees into agricultural systems will improve their sustainability and provide environmental benefits.

Efficient wood and fibre processing

- Reduced costs of production and reduced environmental impact
- Managing the changing forest resource
- Increased end-product performance.

These will enhance the sector's international competitiveness, reduce its current annual trade deficit of approximately $2 billion and provide new opportunities for domestic industries.

New products and markets

- Research will be important in adding value to wood and fibre resources in Australia.
- New composites and products using residues will be developed for domestic and international markets.
- Understanding fibre quality will lead to improvements in paper recycling.
- Product and component performance will be critical to maintaining competitiveness.

Forestry, Wood and Paper Industries

Major objectives and key outcomes

The sector advisory committee assessed the relative attractiveness and feasibility of the sector's nine research areas and agreed on priorities. These are presented below, together with objectives and key outcomes for the 1997–98 to 1999–2000 triennium.

CSIRO's R&D for the sector focuses on a balanced portfolio of strategic and applied research across selected elements of the business system, from resource through to product. Several of the research purposes are linked through objectives and key outcomes. For example, achievement of performance and quality outcomes in solid wood, composites, pulp and paper, recycling and furniture is partly dependent on objectives and outcomes in breeding, silviculture and harvesting.

Industrial plantations

Priority decision

Focus research on improving international competitiveness by lowering production costs, improving resource quality in line with product performance needs and with environmentally sustainable management. Maintain appropriation funding and external earnings to at least 40%.

Objective

Assist Australia's forest industries by improving the yield and quality of wood from plantation forests, lowering the cost of growing, maximising environmental benefits and ensuring sustainable production.

Outcomes

- Increased international competitiveness through continuous improvement in plantation productivity
- Genetically transformed eucalypts to improve adaptability, productivity and pest and disease resistance in plantation eucalypts
- Increased productivity of existing plantations through improved management of light, water and nutrients
- Improved predictive capability for wood yield
- Improved management of water resources including water use by plantations
- Sustainability of plantations
- Improved silvicultural practices for increasing wood and product quality of existing radiata pine plantations
- Improved wood quality through reduction of stem degrade associated with pruning and thinning.

New plantations (farm forestry)

Priority decision

Research to ensure that forestry is competitive with other rural land uses. Education and technology transfer, which are critical to successful uptake and economic analysis, will be important to focus research on commercial success. Maintain appropriation funding with external earnings at least 40%.

Objective

Assist the development of environmentally and economically successful farm forestry in selected regions with the provision of appropriate production methods and technologies.

Outcomes

- Better establishment and increased productivity of tree plantations on farms
- Increased use of high-quality genetic material on farms
- Improved management of catchment water balances and enhanced establishment and growth of trees in salt-affected landscapes
- Increased establishment and efficient management of plantations for waste disposal
- Reduced losses in farm and industrial forestry plantations due to pests and diseases.

Native forests

Priority decision

Key priorities are silvicultural systems that enhance productivity while protecting the environment and relevant, objective and cost-effective indicators of sustainable forest management. Use science base to assist policy development and implementation (e.g. in CRAs—see below). Maintain appropriation funding recognising the high level of public benefits, and increase external earnings from 23% to 30%.

Objective

Provide options for ecologically sustainable wood production from privately and publicly owned native forests for implementation by forest managers; be responsive to R&D needs generated by the current Comprehensive Regional Assessment (CRA) process and the Regional Forest Agreements (RFAs).

Outcomes

- Enhanced productivity in wood production forests
- Protection and conservation of forest soils, biodiversity, water and other environmental values in commercially used forests
- Efficient and effective fire management
- Improved management of disturbed tropical forests.

Harvesting, roading and transport

Priority decision

Focus on the environmental impact of alternative harvesting and planning methods. Priority research includes minimising on-site and off-site impacts of harvesting, and improving harvest planning in terms of economic and environmental outcomes. Allocate appropriation funds selectively and increase external earnings from 26% to 37%.

Objective

Reduce the mill door cost of raw material to industry and minimise environmental impacts associated with harvesting, roading and transport operations.

Outcomes

- Improved harvest planning and operational guidelines for balancing environmental protection and reducing harvesting and roading costs
- Improved harvesting methods and systems to minimise site impact, reduce extraction costs and increase efficiency
- Reduction in direct impacts on forest soils and water quality associated with different harvesting techniques
- Increased recovery of timber volumes and high quality wood during harvesting.

Solid wood—softwood and hardwood

Priority decision

R&D aimed at winning new markets. Develop predictive capacity based on modelling of wood performance. Consider work in life cycle analysis. Maintain appropriation funding and increase external earnings from 16% to 30% in line with industry growth and restructuring.

Objective

Assist the industry to improve the efficiency of its resource use in the manufacture of high-quality and high performance appearance and engineering products and to enhance the international competitiveness of wood products.

Outcomes

- Recovery of value-added products (eg sawn wood and veneers) from low quality hardwood resources
- A viable hardwood processing industry producing high-value appearance and engineering timbers from regrowth and plantation-grown resources
- Improved recovery efficiency in sawmilling operations, especially drying, for high-value products.

Composites

Priority decision

Focus on research to aid cost reduction and quality improvement in an increasingly competitive international panel market and to assist adaptation of technologies to Australian resources. Allocate appropriation funds selectively and increase external earnings from 24% to 40% by 1999–2000.

Objective

Provide new products and processes that utilise silvicultural and mill residues and improve production efficiency and profitability.

Outcomes

- Maximise the utilisation of mixed hardwoods and other forest and mill residues in composite products for domestic and export markets
- Adhesives from natural products
- Hybrid wood-based composites.

Pulp and paper

Priority decision

Focus research on reducing costs and improving performance. Link paper quality research to tree breeding and growing conditions. Refine focus with further industry consultation. Maintain appropriation funding and external earnings to at least 40%.

Objective

Improve product performance and minimise the costs and environmental impact of processes.

Outcomes

- Improved utilisation of hardwood and softwood fibre for paper making
- Pulping, bleaching and paper-making operations with minimal environmental impacts
- Optimum applications from the variability in fibre quality—better matching of fibre quality to product needs.

Recycling

Priority decision

Priority areas include fibre quality regeneration and durability, fibre life cycle and fibre waste for energy. Recycling of other wood products will be addressed. Allocate appropriation funds selectively and increase external earnings from 20% to 30%.

Forestry, Wood and Paper Industries

Objective

Investigate variability in the regeneration of fibre properties and develop processing strategies to minimise degradation and upgrade towards virgin fibre quality; to recycle mill material through carbonisation.

Outcomes

- Maximising use of recycled fibres in the paper industry, particularly in higher value grades
- Technologies and methods for economic recycling or re-use of other wood and paper based materials
- Use of wood-based residues for energy and carbon products.

Furniture and other 'appearance' products

Priority decision

Priorities include evaluation of Australian timbers for furniture, and timber performance under various environmental conditions and end-uses. Allocate appropriation funds selectively and increase external earnings from 28% to 40%.

Objective

Extend the use and enhance the performance of Australian timbers in high-value furniture and other appearance products.

Outcomes

- Suitability of timber from young or fast grown trees for use in high value furniture and appearance products
- Optimal veneering procedures for the production of panels for use in furniture
- Acceptable creep behaviour in wood-based panels under various environmental conditions
- Techniques for non-destructive evaluation of wood panels.

Customers, technology transfer and commercialisation

CSIRO maximises the transfer of research outcomes by actively involving customers in all stages of the R&D process. Adherence to procedural rigour in all projects will hasten technology transfer. Major customers and stakeholders include large corporations, small and medium-sized enterprises (SMEs), the Federal Government, R&D corporations, State forest management agencies, industry associations and non-government organisations. CSIRO collaborates with forestry and forest product research institutions in many countries, especially in the Asia-Pacific region, and with international centres and organisations. CSIRO is the major partner in two CRCs. Forest and forest products research extends non-priced benefits to the community.

Technology transfer is aided by publications, client reports, decision support products, field days, conferences, training courses and seminars. New projects will specify a technology transfer objective and strategy. The Sector Advisory Committee will assist the successful implementation of the sector's strategy. Involvement with Standards Australia in evaluating wood and wood products performance aids the transfer of research results.

Licensing and patenting will be integral parts of the sector commercialisation strategy. While serendipitous research outcomes are expected to continue to provide spin-off opportunities, strong market focus will ensure that protection and management of intellectual property is an integral part of project development.

Marketing and communication

Sector **marketing** will increase the use of CSIRO research, expanding collaboration in research and increasing research funding from industry. Strategies include early and on-going consultation with industry to identify and prioritise research needs, promotion of CSIRO as an independent source of scientific input in policy development, and establishment of strategic associations with industry, community groups and other research providers.

The main objective of the sector's **communication** strategy is to raise national awareness of the importance of science and technology in the sustainable management of Australia's forest resources and the opportunities for adding value in forest products processing and manufacture. Communication is tailored for different target groups, including forest owners and managers, forest product processors and users, policy makers and the general public. Participation and representation in various industry committees, programs, inquiries and the Australian Forestry Council facilitate communication to stakeholders. CSIRO's World Wide Web site (through CSIRO Forestry and Forest Products) will be an increasingly important communication medium. Onwood (the division's R&D update magazine) will be expanded to encompass the research activities of the sector.

Development of CSIRO's R&D capacity

Major areas of this development over the triennium will include molecular biology, enhanced skills in the application of information technology (such as GIS), rapid measurement of wood fibre properties and interpretation of this information in relation to tree improvement and product quality, and short- and long-term product performance assessment.

The strategic directions of the sector will be accommodated in divisional workforce planning, succession planning and staff recruitment and development. Regular consultation among the participating divisions ensures that R&D capacity is continuously evaluated.

CSIRO will continue to rely on significant in-kind contributions from industry to overcome limitations on resources and facilities available to the divisions in the sector.

Performance and evaluation measures

The performance of the sector will be judged on its research achievements against planned outcomes. Other key performance areas assessed and attendant performance indicators include:

Technology transfer: uptake of research outputs, publications, reports, conferences, seminars, training programs, workshops and customer satisfaction surveys

Commercialisation: patents, intellectual property protection, licences, successful contract completion

Marketing: actual external earnings relative to the sector target of 37% by 1999–2000; repeat business

Communication: media coverage; responses to articles in specific publications and the WWW

R&D capacity development: change in resource allocations to priority areas; numbers of students and post-doctoral students; collaboration with other researchers; acquisition of new skills.

Research evaluation will be strengthened over the triennium in consultation with clients. Cost-benefit analysis will be applied to new research proposals and selected completed projects. An evaluation strategy will be developed for the sector to ensure that returns from research investments are optimised for the long term. Greater use of economic analysis of options will be applied in appropriate research areas.

Sector coordinator

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Divisional participation

Forestry and Forest Products, Plant Industry, Entomology, Land and Water, Wildlife and Ecology, Mathematical and Information Sciences, COSSA.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	15.1	15.8	16.2
External funding	9.1	9.1	9.2
TOTAL	**24.2**	**24.9**	**25.4**
External/total ratio	37%	37%	36%

Sector Foreword

It is my pleasure, on behalf of the CSIRO Horticulture Sector Advisory Committee, to present the Horticulture Sector Plan for the triennium 1997–1998 to 1999–2000.

The plan is based on an underlying theme of low-input production systems which will be financially and environmentally sustainable. In response to the need to focus more clearly on the ultimate customer, the consumer, this plan incorporates a new project initiative aimed at developing new, non-invasive technologies for management of post-harvest quality. It also incorporates a strengthening of tropical horticulture in the areas of pest management, plant growth management and water/nutrient use efficiency. This initiative in particular is strongly supported by regional industries.

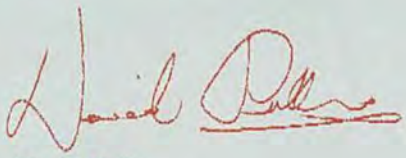
Members of the Horticulture Sector Advisory Committee are enthusiastic about the future for horticultural production in Australia and the importance of new technology development in enhancing industry's competitive advantage. The excellence of the science performed by CSIRO for the horticultural industries is acknowledged as an integral ingredient in plans to address the future.

Australia is ideally placed to meet the changing food tastes of people in the rapidly developing Asian economies. National activities such as 'Supermarket-to-Asia' and an increasing number of professional producers are clearly aimed at addressing this potential. Horticultural exports of a wide range of fruit, vegetables, herbs, flowers, nuts and wine totalled $1.02 Bn in 1995–96. Future export growth will be fundamentally linked to technology development in the areas of genetic improvement, improved low-cost production systems and financial and environmental sustainablity. CSIRO must actively anticipate the required technologies which will back Australia's international competitiveness, export growth and resource security far beyond the next triennium if technology development, with its relatively long lead times, is not to lag behind policy.

A shift in the balance of research activities toward the consumer end of the business chain is being addressed. We expect to generate an increase in the proportion of non-RIRF (rural industry research fund) funding and an overall increase in diversity of the customer base. To deliver the Plan the Sector will need to provide assistance and some leadership to industries in identifying their research needs. An emphasis on industries or enterprises with effective peak bodies or strong corporate management who have a clear vision for the future is recommended. CSIRO is also well placed to pursue multi-disciplinary research opportunities with potential for spillover across a number of industry segments.

In achieving the Plan's targets it will be vital to provide sufficient resources to adequately communicate with the various industry sectors. In horticulture these are diverse. Members of the Sector Advisory Committee are keen to assist but the central task remains with the Executive and senior staff within the Sector. The importance of good communication in developing a clear understanding of the R&D needs for the various sectors and providing an insight to the broad skills base within CSIRO cannot be emphasised enough.

Yours sincerely



David Pullar
Chair, Horticulture Sector Advisory Committee

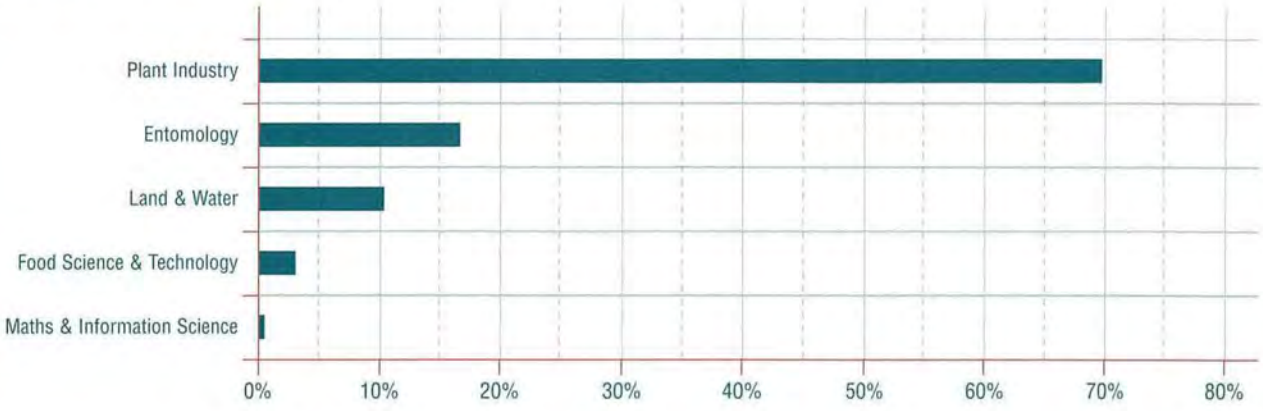
Horticulture Sector Advisory Committee:

David Pullar (Chair), David Pullar & Associates; *Bob Calder*, Dept of Primary Industries & Energy; *Edwina Cornish*, Florigene Pty Ltd; *Peter Pokorny*, Woolworths Ltd; *Tony Biggs*, Rural Publishers Ltd; *Brian Carroll*, Ausveg Board; *Phillip Laffer*, Orlando-Wyndham Pty Ltd; *Paul Ziebarth*, Qld Fruit & Vegetable Growers Board.

Horticulture

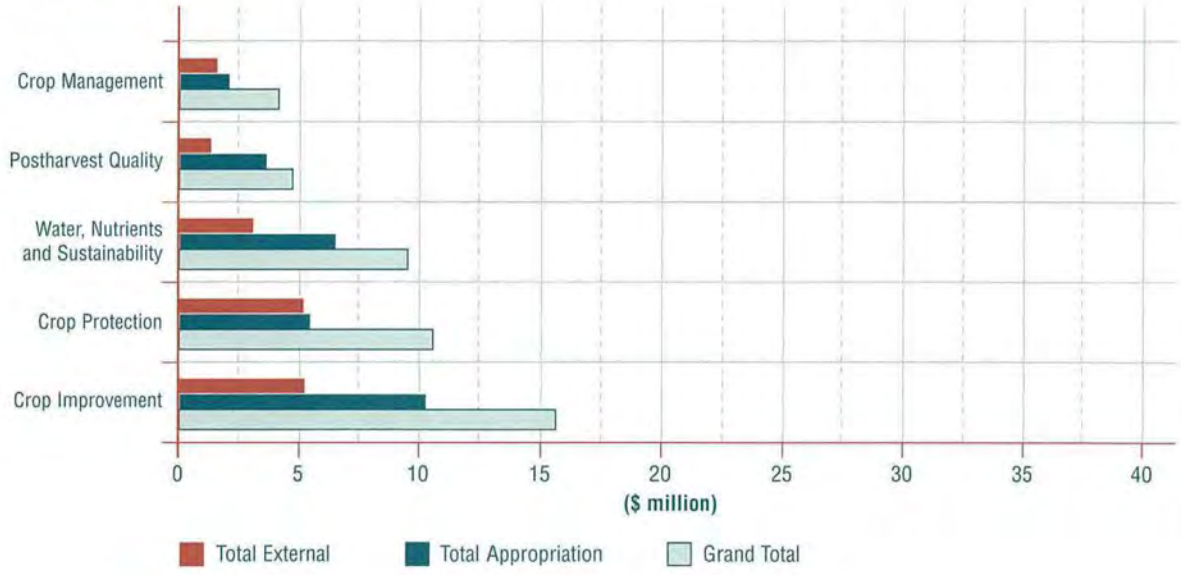
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $44.98 million)



Triennial Investment by Component

(Total Sector Investment $44.98 million)



'There has been increasing interest in the production of horticultural crops throughout the world . . . Fresh horticultural crops are often identified as a commodity group for which there is high demand, which are of value nutritionally and have potential for local and export markets. They are of economic importance because they fetch relatively high prices when compared to staple agricultural commodities, can increase foreign exchange earnings, and are a potentially significant source of employment in rural locations.'

The British Council 1996

Mission

To use conventional and new technologies in production and post-harvest research to increase the competitiveness, profitability and environmental sustainability of Australia's horticultural industries.

Overview

CSIRO has faith in the potential of Australian horticulture. Among the nation's agri-industries, it has the second largest GVP after beef, with rising export performance. Current trends indicate a growth in exports of fresh fruit and vegetables from $533 million to about $800 million and wine from $450 million to about $800 million by the year 2000. Funding available for R&D through the Horticultural Research and Development Corporation (HRDC) has risen from under $0.5 million to over $23 million in the last eight years.

Issues and research opportunities

Australia is geographically situated among the fastest growing economies on earth and CSIRO must be alert to the opportunities this provides. Horticultural production, processing and export will increasingly be driven by consumer demands for quality, variety, appeal, taste, reliability, availability and safety. These imperatives affect decisions at each stage between field and consumer.

Although CSIRO is not in a position to address all of the current challenges facing different segments of the horticulture sector, it has an important role to fulfil as a major provider of strategic and cross-disciplinary research. In supporting Australian horticultural industries to strengthen, maintain, or develop world class status, the following factors need to be emphasised as critical to success;

- environmental and economic sustainability
- scrupulous quality and safety ('clean, green')
- continuing dialogue with industry; and
- cooperation with other research providers.

As well as its hemisphere advantage, Australia has a unique position as the only developed country with significant arable land in the tropics. This can be exploited by developing sustainable management strategies for improved crops, on what are often fragile tropical soils. The diversity of Australia's indigenous plants can also be used to differentiate some Australian produce and introduce new characteristics.

It is important that CSIRO's expertise and resources are accessible—not only to 'high performance' industries such as grape and wine but also, on a selective basis, where specific R&D plans exist and needs are not already being met by other providers such as State departments, to the emerging industries of the future and those industries that are restructuring to become more efficient and profitable.

With advice from the Horticulture Sector Advisory Committee, CSIRO has determined that the following areas of major research opportunity best match the sector's skills and capabilities:

- **efficient use of natural resources**
  - — optimal application of irrigation water
  - — prevention of soil degradation
  - — re-use of effluent and other wastes
  - — understanding and management of soil fertility
  - — innovative uses for by-products
  - — remediation of degraded and contaminated sites.
- **reducing chemical inputs**
  - — integrated pest management, biocontrol
  - — biotechnology-genetically conferred pest and disease resistance
  - — optimal application of fertilisers/chemicals
  - — non-chemical disinfestation.
- **maintaining competitiveness for producers** (consistent supply and quality of domestic and export produce)
  - — 'designer plants' and novel products
  - — improved varieties suited to consumer needs and Australian conditions
  - — manipulation of plant development processes
  - — better harvest, handling and storage systems

— packaging materials to improve quality and shelf life and minimise waste
— non-invasive testing of quality parameters such as sweetness, ripeness, respiration rate
— better management of production processes
— value-adding.

Areas of particular opportunity are:

- **applications of new technologies**
  — support systems for on-farm decision-making
  — long range crop forecasting/shorter term monitoring
  — genetic engineering.
- **exploiting the potential of tropical horticulture**
  — regionally adapted tropical tree crops
  — managing fragile environments
  — orchard design and management
  — utilising Australian biodiversity.

Components of the sector plan

The research for the sector has been grouped into five components based on a vertically integrated business chain—'paddock to plate'—through natural resource inputs, planted crop materials, production and protection of crops, to quality management in the value-adding chain. These components, and the strategies to be pursued in addressing them, are:

Water, nutrients and sustainability

Misuse of the resource base in the past has led to major problems including soil degradation, increasing salinity, and eutrophication. These problems highlight the urgent need for 'smart' farming to minimise inputs without sacrificing yield and quality. This applies to all intensive horticultural systems and particularly in matching crops to appropriate regions. In future, decision support systems will enable prospective land users to determine what activities can be sustained on specific types of land. CSIRO is investigating the critical parameters for this process, using a range of temperate and tropical crops including cashews, grapevines and tomatoes.

Strategies: *soil and nutrient analyses; modelling of water, salt, nutrient movements; irrigation systems.*

Crop improvement

There is significant earning potential for Australian producers in the Asian region for good quality fresh fruit and vegetables, a high demand for extended shelf life, improved crops such as seedless citrus and sweeter melons, and a need for reliability of supply and a good range of produce with extended seasonality. Mastery of genetic transformation technologies will have profound consequences—enabling very specific changes to be made in elite crop varieties. Technology and new cultivars can be licensed to provide ongoing income.

Strategies: *gene technologies for specific improvements of selected crops; conventional breeding for improved and new varieties.*

Crop management

The wine industry has projected a doubling in grape harvest (from 850 000 tonnes to 1650 000 tonnes) by 2025 to achieve their target of 6.5% of world production. This will entail finding 70 000 additional megalitres of water for irrigation. Research into plant physiology and hormonal response to stress has already demonstrated that a reduction in irrigation levels of up to 50% is feasible. Other developments and strategies which benefit growers are yield forecasting, rootstocks which restrict salt uptake and resist disease, management of canopies for fruit production and disease control, better understanding and control of flowering, pollination and fruit set.

Strategies: *plant physiology, biochemistry and molecular biology for manipulating crop development; trace element/nutrient needs analysis in crops; new IT applications: decision support systems (DSS), crop modelling and forecasting.*

Crop protection

Environmental benefits and cost savings will flow from reduced reliance on biocides in crop production and post-harvest handling, giving increased options for pest and disease control and leading to an enhanced 'clean, green' reputation for export. International cooperation will ensure up-to-date knowledge of global pest and disease control issues, so that CSIRO can respond rapidly to outbreaks which threaten Australian industries and those of the immediate region.

Strategies: *pest and disease physiology and pathology; systematics of insects/ arthropods, especially pests and biocontrol agents; new IT applications; DSS, modelling.*

Post-harvest quality

Post-harvest handling practices, including storage and transportation, disinfestation and shelf life will determine the state and therefore value of Australian produce locally and overseas. Consumers expect their purchases to be undamaged, uncontaminated and tasty. These expectations are becoming standard, particularly for goods exported to countries with stringent regulations

like Japan. Australia needs to improve its reputation as a reliable producer of quality fresh produce.

Strategies: *plant responses to storage and modified atmospheres; new non-invasive testing technologies.*

Major objectives and key outcomes

- **Irrigation management** strategies based on actual plant water use and weather data.
- **Enabling technologies** for horticulture based on biotechnology and plant physiology—particularly the ability to reliably manipulate characteristics such as taste, colour, sweetness, disease and pest resistance, softening, browning and seedlessness.
- **Gene constructs** derived from virus genomes for **plant protection and genetic manipulation.**
- **Plant growth models and decision support systems (DSS)** to manage yields and optimise production.
- **Reduced use** of fungicides, insecticides, fumigants, fertilisers and other chemicals.
- **Biocontrol** of significant insect/arthropod pests of Australasian crops including use of synthetic attractants.
- **Improved handling** and HACCP protocols for fresh produce and minimally processed foods.
- **Control of post-harvest diseases**, especially in tropical fruits.
- **Non-chemical methods of disinfestation** to satisfy requirements of major overseas produce importers.
- **Non-destructive technologies for assessment** of quality and ripeness parameters in fruit and vegetables.
- Justified reputation as **'clean, green'** producer and exporter of horticultural produce.

Customers and technology transfer

The most successful industry segments (wine and dried fruits), currently CSIRO's main customer base, are highly professional, have strong, focused leadership, understand the value of R&D, and plan their own research needs. They now dictate exactly what they want from research providers. In the industry as a whole, levels of technology adoption are variable. Examples from both ends of the range are—dried fruit packers, whose response to innovations or changes are quick and unanimous, and some groups of vegetable growers who, through limited organisation, geographic dispersion and, possibly, language barriers can be slow to take on new practices.

While recognising that the viticultural industries are exceptional, CSIRO believes other groups will achieve similar success with assistance. CSIRO's challenge is to work with these other groups on developing R&D as a crucial component of industry development. It is essential that industry and researchers are equally excited by the benefits of research. This will require better communication of roles, technologies, processes, science and, generally, CSIRO's capabilities for industry.

Industry umbrella organisations can be very important in facilitating technology transfer to members and providing advice about grower/market needs and problems. Where possible, CSIRO interacts directly with growers and their associations via, for example, field days, meetings, and project planning. Generally, it is represented at such events by industry 'champions'—high-profile researchers who are acknowledged as valuable sources by the industry in question. (Industry groups with which CSIRO interacts in this way include citrus, viticulture, macadamia, and others).

As research funding comes increasingly from private companies—multinational retailers, food processors, seed producers, chemical manufacturers—the commercialisation route also changes. Industry partners often have sophisticated and successful marketing arms which are able to commercialise a new product very efficiently.

There are potential earnings to CSIRO from new plant varieties, genetic technologies, chemical treatments and processes, and the organisation is becoming more adept at putting in place intellectual property safeguards. Where appropriate, CSIRO pursues patents, plant breeders rights and other means of maximising the return for investment in research.

One specific area in which marketing and communication will play a critical role is public acceptance of genetically modified food plants. Consumer organisations are (rightly) asking for reliable and comprehensible information about the technologies involved, in an effort to enable the public to make informed decisions on this important issue. CSIRO should be part of this debate.

The Horticulture Sector Advisory Committee has offered to assist CSIRO in marketing its R&D capabilities to the horticultural industries, probably commencing early in 1997.

Horticulture

Development of CSIRO's R&D capacity

CSIRO will emphasise acquisition of new skills in:

- eco-physiology, plant growth and development in response to the environment
- post-harvest physiology as it interacts with control of quality parameters, ripeness, senescence etc.
- plant growth modelling, as it interacts with crop assurance and robotic crop management
- bioinformatics and database manipulation.

Evaluation of performance

Evaluation will be according to CSIRO's general key performance indicators. This means:

- shift of resources according to agreed priority decisions
- external earnings for research and services
- contracts successfully completed in current financial year as proportion of total completed
- adoption by users of practices, instruments and processes developed by CSIRO
- level and quality of publications—books, papers, patents, commercial reports and citations
- number of postgraduate students (jointly supervised), fully or partially sponsored by CSIRO.

Sector coordinator

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Divisional and other participation

Plant Industry (97.5 EFT), Entomology (17 EFT), Land and Water (18.1 EFT), Food Science and Technology (3.8 EFT), Mathematical and Information Sciences (Biometrics Unit) (1.5 EFT).

Rural Industries R&D Corporations: HRDC, DFRDC, RIRDC, GWRDC, CRDC, GRDC, LWRRDC.

Commercial firms: Woolworths, Zeneca, Rhône-Poulenc, S & G Seeds (Sandoz), Gene Shears, Smith Snackfoods, Phosyn, Pioneer Seeds, SPC.

Growers and grower associations: Australian Mushroom Growers Association, Australian Macadamia Society, Queensland Fruit and Vegetable Growers, Australian Dried Fruits Association.

Federal Government Departments: DIST, DEETYA, DFAT and statutory bodies—NIH, ACIAR.

Regional and national land management agencies: MDBC, MIA, NRMS, ANCA .

Other sponsors: Baker Trust, Vic.

Cooperative Research Centres: Viticulture, Plant Science, Tropical Pest Management, International Food Manufacture and Packaging Science, Soil and Land Management, Tropical Plant Pathology (co-participants and sponsors).

State departments of Agriculture and **universities** in Australia and overseas (co-participants).

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	9.1	9.5	9.7
External funding	5.4	5.4	5.7
TOTAL	**14.5**	**14.9**	**15.4**
External/total ratio	37%	36%	37%

Meat, Dairy and Aquaculture

Sector Foreword

I am writing as Chairman of the Sector Advisory Committee for Meat, Dairy and Aquaculture, to comment on the Sector Plan for the period commencing in the 1997/98 year.

The Committee fully supports the concept of sector planning and, subject to the comments late in this letter, supports the sector plan prepared for presentation to the CSIRO Board in April 1997.

The Committee recognises that the introduction of the sector planning process has significantly increased workloads for many CSIRO personnel, and specifically wishes to thank Phil Jennings and, more lately, Shaun Coffey for their efforts in this regard. The Committee suggests that CSIRO should evaluate the potential to streamline systems for data collection, as well as assess the value added from the sector planning process in terms of better priority setting and more efficient resource allocation, against the additional resources required for the process itself.

As you will appreciate, time constraints in the planning process, coupled with the inevitable inertia in research programs, have meant that the Committee has had little impact on the establishment of priorities in the present plan, especially in relation to 1997/98. We plan to have a greater influence in future years, by concentrating particularly on such matters as:

- seeking justification for the relative amounts of appropriation funds that are allocated to the various segments within the sector
- seeking to understand the extent to which research priorities, and hence allocation of appropriation funds are influenced by external bodies such as RDC's, and
- ensuring that projects and programs, when established, have clearly defined benefits and milestones, and procedures for regular review and audit of those benefits and milestones.

Finally, let me on behalf of the Committee, congratulate you and your staff on a good start to the very worthwhile initiative of sector planning.

Yours sincerely

John S Keniry
Chair, Meat, Dairy and Aquaculture Sector Advisory Committee

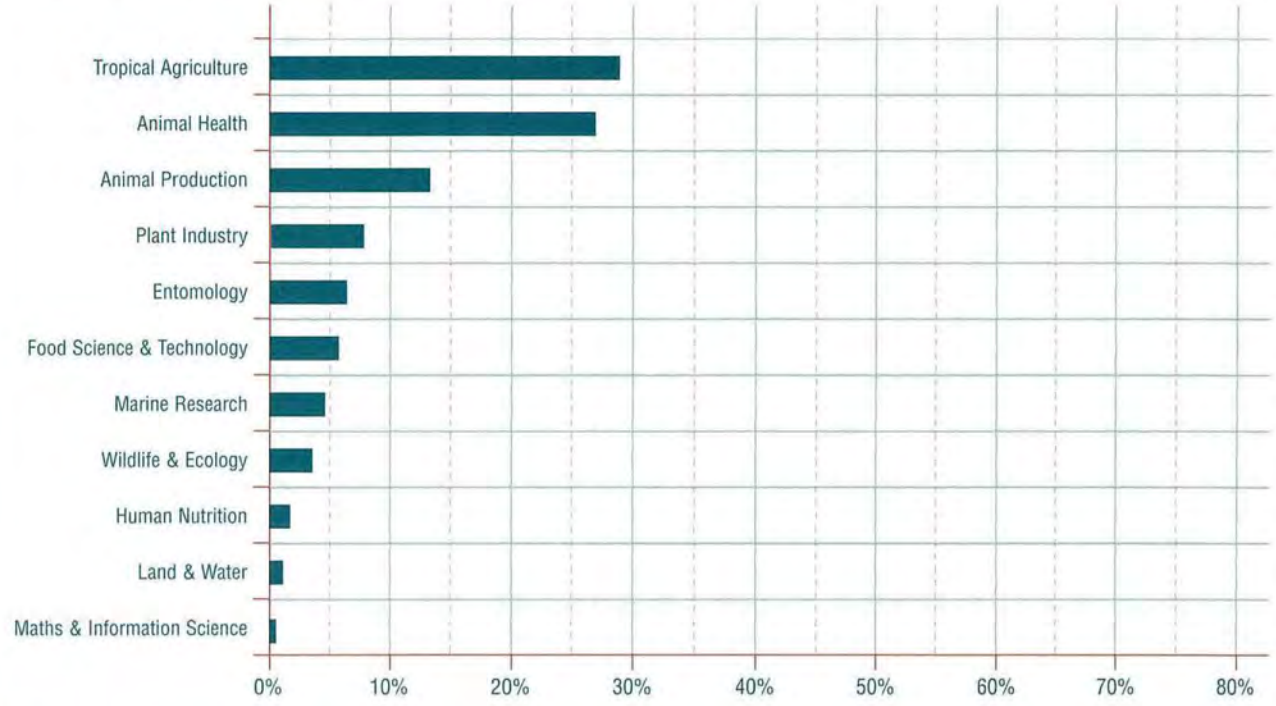
Meat, Dairy & Aquaculture Sector Advisory Committee:

John Keniry (Chair), Ridley Corporation; *Ted Christie*, Barrister & Environmental Lawyer; *Robin Hart*, Kerwee Pastoral Company; *Wendy Miller*, Veterinarian & Beef Producer; *Wayne Sanderson*, Murray/Goulburn Co-Op Co Ltd; *Ervin Vidor*, Sea Farms Ltd; *John Landy*, Meat Research Corporation; *Gardner Murray*, Dept of Primary Industries & Energy; *Shane Walsh*, Beef Producer; *Tony Wharton*, Q-Meat

Meat, Dairy and Aquaculture

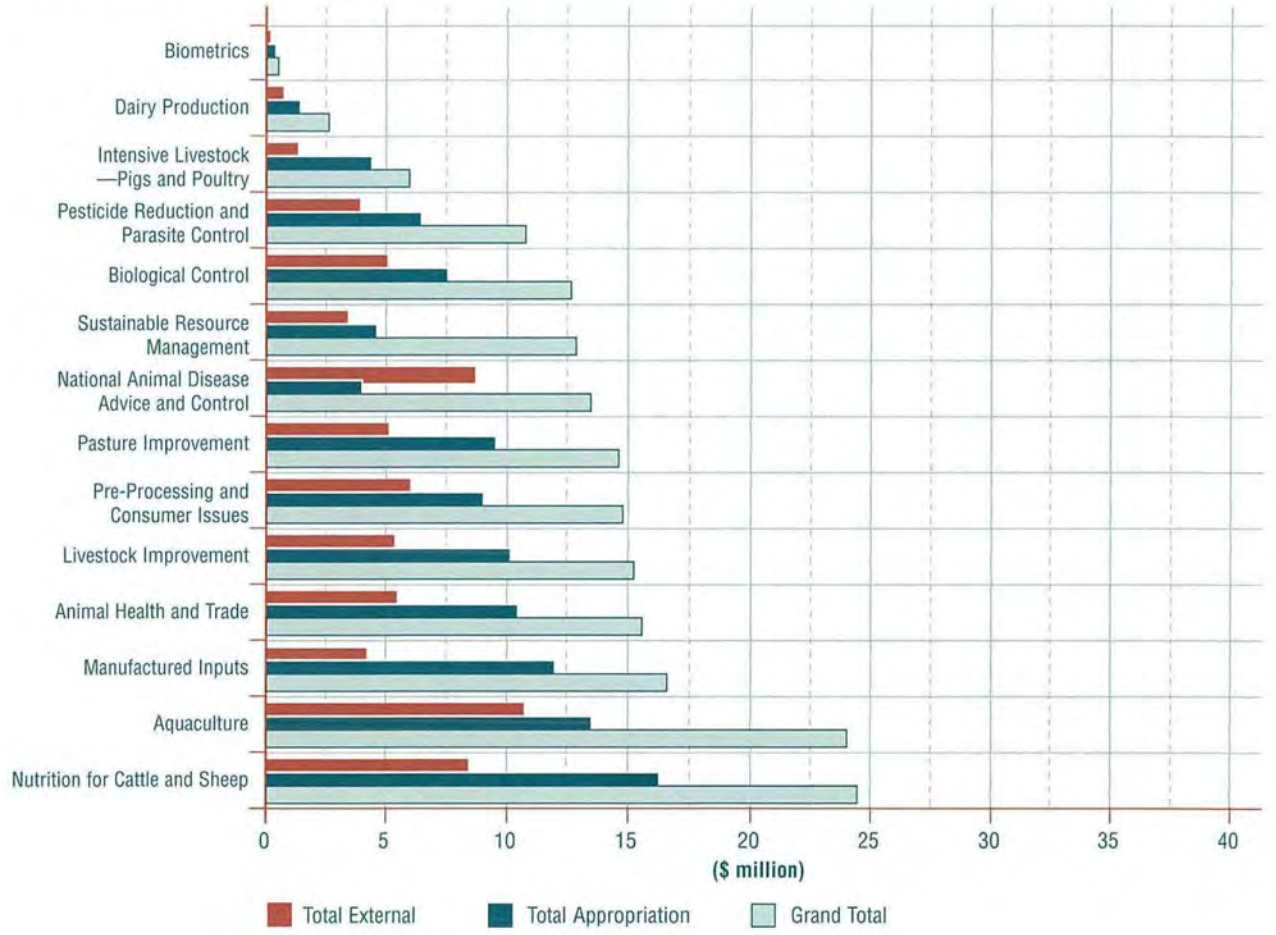
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $180.27 million)



Triennial Investment by Component

(Total Sector Investment $180.27 million)



Meat, Dairy and Aquaculture

Mission

To deliver new products and better solutions to technical and management problems in the Meat, Dairy and Aquaculture industries.

Overview

Australia's meat, dairy and aquaculture industries produce more than $13 billion of products each year and bring in $6.5 billion in export earnings. This sector encompasses red meat (beef and sheep), pigs, poultry, new animal industries and dairy products, and aquaculture of fish, crustaceans and shellfish.

The meat, dairy and aquaculture sector is Australia's third largest direct export earner. The viability of the large, value-adding food processing sector depends on it. It is a major provider of employment, contributes to national well-being through high-quality and safe products, and is a mainstay of Australian rural life and social infrastructure.

CSIRO's research in the meat, dairy and aquaculture sector covers efficient production, sustainable resource use, manufactured inputs and market and consumer issues.

This sector has shown sustained growth and increase in productivity. Exports from the sector have grown from $2.6 billion to $6.5 billion over the last decade. Future growth is expected to remain strong and will come from providing premium high quality protein to increasingly affluent and discerning customers, particularly in Asia. The sector is responding to the challenge of these export markets by developing and marketing quality, 'clean' products. These products will be quality-assured from paddock to plate, and will be provided to a precise consumer specification that includes responsible custody of the environment. Government policy, new environmental management standards (ISO 14000) and post-GATT trade agreements place increased emphasis on natural resource management and environmental issues.

The increased demand for new technology by this sector matches the increased technological opportunities afforded by the new agricultural biotechnologies and information technology. CSIRO's capacity to serve these needs is combined with effective mechanisms for retaining the benefits for Australia. CSIRO has a clear role and can make a huge difference.

CSIRO's primary strategy for its future in the sector is to develop exciting new products, technologies and production systems in a cost-effective and environmentally sustainable fashion.

Eleven CSIRO divisions operate in the sector, with a comprehensive research capacity and strong links with major collaborators: the State governments, the Commonwealth Department of Primary Industry and Energy, and several CRCs. It is also a major contributor to national policy development in animal and fish health and environmental management.

CSIRO is the largest research provider in this sector, well differentiated from other providers who are for the most part its collaborators; it is well placed to assemble and manage multi-disciplinary teams. CSIRO is uniquely capable of addressing important industry and national issues such as market access and environmentally sustainable production systems, and can respond quickly to national imperatives identified by the Federal government.

Major objectives and outcomes

The major objectives for CSIRO in the sector are:

- to develop the technologies that will help the sector enhance international competitiveness
- to develop the technology and systems for ecologically sustainable development
- to help maintain market access by reducing the risk of non-tariff barriers, including disease status, food safety, nutrition and environmental concerns
- to develop manufactured inputs that enhance the efficiency and profitability of the industry, reduce chemical inputs and have commercial potential for Australian business.

The major outcomes that CSIRO seeks for the sector are:

- to ensure Australia maintains its enviable animal health status, through a rapid diagnosis and management response to potential outbreaks of exotic and new diseases and by maintaining quality assurance of related testing
- to enable Australian products to continue to access international markets, through testing and assurance of food safety (from both biological and chemical aspects)
- to enable the expansion of the aquaculture industry, through an integrated research effort to develop basic understanding of biology, health, production systems and market needs
- to ensure that there is an adequate supply of livestock that meets market specifications (especially in terms

of product quality), through the application of novel genetic and reproductive technologies

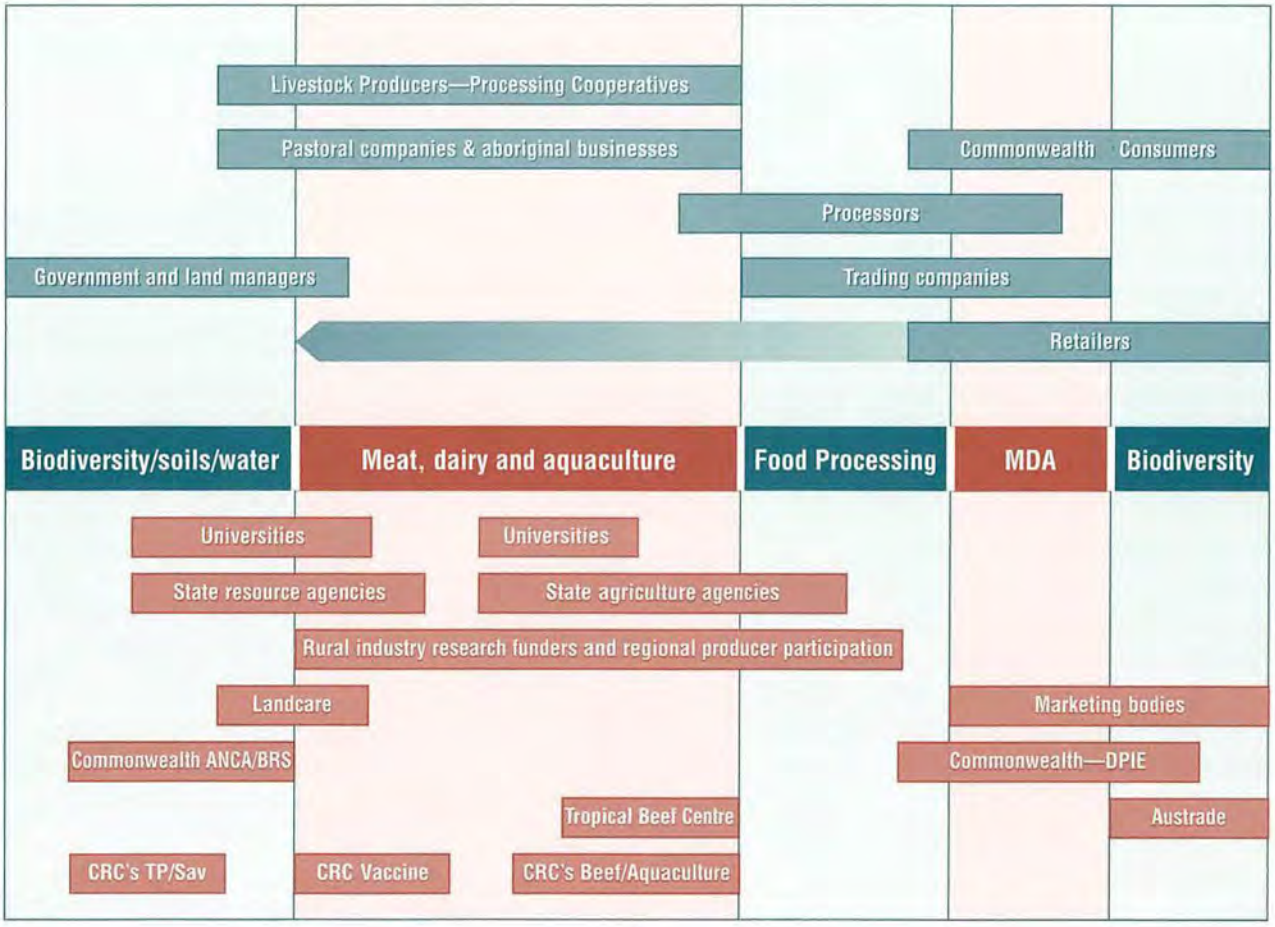
- to ensure that established industries continue to remain competitive, through the application of new technologies in nutrition, health, welfare and management, and through development of new production systems for both extensive and intensive production
- to provide a feedbase sufficient to meet the needs of the livestock industries, through the development of improved pasture and fodder species, the modification of fibre and/or rumen manipulation
- to reduce reliance on chemicals, through the application of genetic disease resistance and by devising new production systems, including the application of biological control measures
- to provide for sound resource management, through the development of management strategies aiming to achieve sustainable production, by maximising desirable attributes such as biodiversity, and through a general improvement in knowledge of ecology and ecosystem functioning
- to enable customer satisfaction to be achieved through improved production and handling systems
- to achieve better quality and consistency of products being marketed.

Customers, technology transfer and commercialisation

The sector has a wide variety of customers—from all levels of government, most rural research funds, and a large range of commercial interests. The Commonwealth Government is the main customer, through both direct appropriation funding and indirect mechanisms such as DPIE and its agencies. The government and industry are significant customers also through the rural R&D corporations. Besides these, CSIRO provides services to commercial organisations such as feed companies, seed merchants, veterinary and other pharmaceutical companies, and meat and fish processors.

The users of research outcomes include every section of the meat, dairy and aquaculture pipeline as shown in the diagram below.

The MDA pipeline: users, sectors, customers/collaborators/competitors



Technology transfer and commercialisation are necessarily addressed at a component level, as the diversity of this sector precludes whole-of-sector planning. Nonetheless there are trends worth identifying.

Most of the customers (e.g. government agencies and the rural research funds) in the sector invest in CSIRO research on behalf of widespread clients. CSIRO's research in these areas only brings a return to its customers if the research outcome is successfully transferred to livestock producers. There is limited vertical integration in the pastoral industries, so the technology transfer targets include more than a hundred thousand small to medium enterprises across rural Australia. This requires effective use of existing State, industry and community networks in addition to selective CSIRO-driven technology transfer activities. Participating Divisions will be encouraged to share their existing networks across components.

Commercial interactions are also a significant feature of the component. The advantages of developing key account contacts will be assessed in the first year of the triennium.

Marketing and communication

Marketing CSIRO's capabilities

CSIRO has highly marketable capabilities across the sector and a requirement to increase external earnings to 40%. A coordinated plan to market CSIRO's capabilities will be developed with the Agribusiness Alliance and divisions in the sector. The plan will include

- CSIRO/Federal Government workshops
- coordinated participation in industry events such as MRC's 'meat profit days'
- international marketing via 'Food into Asia'

Research support and public awareness

Many projects within the sector require marketing and communication support to achieve their objectives.

While most of this work will be initiated at a project and divisional level, there is significant overlap in the target audiences of many of the components within the sector and the potential to more efficiently and effectively deliver key messages. The sector process will encourage coordination of marketing activities by divisions to ensure that the greatest combined benefit is gained from activities such as newsletters, field days and conferences.

Divisional marketing and communication staff will be encouraged to take a lead role in key components, such as the Marine Research Division for aquaculture. Summaries of the work for the sector will be prepared for the key customers/users by print and publication.

Development of CSIRO's R&D capacity

CSIRO brings a diverse range of skills to the sector, as will be seen in the component research plans. These range through the engineering and biological science, into marketing and product development. As the sector grows to meet that potential market demand there will be increasing needs to develop the skills base at the molecular science and systems integration ends of the spectrum. Changes in the way in which CSIRO is able to conduct its research will result in significant changes in the pattern and nature of the capital investment needed to underpin this research.

Performance and evaluation measures

Performance will need to be measured in four critical areas, or imperatives:

Market and consumer issues

Access to international markets is critical to the success of this sector. This requires maintenance and proof of nutritional composition, food safety, disease freedom, animal welfare and environmental health, as well as meeting the food consumer's quality expectations.

Sustainable resource use

The meat and dairy industries must ensure that they do not further damage Australia's fragile natural resource base. They must increase their efforts to address a range of environmental problems (soil acidity, erosion, salinity, water quality, weeds, pests). There are also environmental constraints on growth in aquaculture.

Efficient production to customer specification

Production systems must accommodate the need to meet customer expectation and must increasingly focus on ecologically sustainable systems. Genetic, pasture and other nutritional technologies need to combine in integrated management systems and technologies for exacting product specification, profitability and ecological sustainability.

Meat, Dairy and Aquaculture

Continued performance in the manufactured inputs

The major components are non-pasture feed inputs and products for animal health and production. CSIRO will have a role in creating opportunities for novel nutritional approaches and products; for example, feeding to alter milk composition, land-based substitutes for aquaculture feeds, cheaper, better feed grains and grain substitutes. Access to therapeutics demanded by Australian industry must be maintained with planning to address risk management and market failure problems.

CSIRO R&D for the sector must be evaluated against these critical factors. The organisation of the research effort of the divisions represented in the sector affords the opportunity to develop a performance matrix for our research. During the first year of the triennium a performance matrix will be developed. This matrix will accommodate relevant CSIRO performance indicators (adoption and impact of research, customer satisfaction, publications and patents, external earnings and postgraduate training) into a framework which recognises these special imperatives for the sector. The specific deliverables identified in each component research plan will be assessed against this matrix, with the relevant division being accountable for achievement of the planned outcomes

Sector Coordinator

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Divisional and other participation

Animal Health, Animal Production, Entomology, Food Science and Technology, Human Nutrition, Land and Water, Marine Research, Plant Industry, Tropical Agriculture, Wildife and Ecology, Mathematical and Information Sciences.

CRCs for: Aquaculture, Cattle and Beef, Tropical Pastures and Savanna, Vaccine Technology, Vertebrate Biocontrol.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	37.3	38.9	39.8
External funding	21.8	21.3	21.2
TOTAL	**59.1**	**60.2**	**61.0**
External/total ratio	37%	35%	35%

Wool and Textiles

An inadequate timeframe between formation of the Sector Advisory Committee (SAC) and the need to endorse the Sector Plan did not allow the Committee to undertake a meaningful review role, let alone an active developmental role in the Sector Plan. The following views are therefore preliminary and subject to change during the triennium. Due to indications that the Sector appropriation budget will remain constant over the Triennium in real terms, and in view of the commitments to external funding sources, the Committee has not sought to reallocate funds within the Sector at this stage. Support for projects can broadly be ranked according to the order of priority shown below. In general the direction of the SACs thinking has emerged quite clearly, and with it associated challenges as further discussed below.

(i) Development of new consumer end products that create product desire and meet performance needs.

(ii) Projects considered critical to economic and environmental sustainability of textile processing.

(iii) Projects of a longer term strategic nature.

Expanded sector focus to include textiles and other fibres

Firstly, the Sector must initiate work in textile areas other than wool in order to be a representative Wool and Textiles Sector, and to reflect consumer demand. This may well encompass fibre blends including wool. At this stage there is neither appropriation nor external funding to do so. High consumer acceptance of wool-blend textiles should enable integrated research projects with private funders of cotton and man-made fibres research. By such direct alliances CSIRO could leverage its own expenditure with the R&D and marketing budgets of those companies and benefit from technology transfer.

Sector to provide interactive technical consulting services to industry

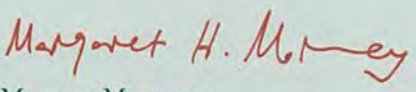
Secondly, there is unanimous agreement that the local and overseas industries need much more direct assistance and that the Sector should build dynamic linkages with industry through increased emphasis on short term product development projects and interactive consulting on a fee-for-service basis. This represents a change from current practice which focuses on longer term strategic projects funded principally by the RIRFs. With the additional risk that RIRF funding may decrease in the future, expansion of sector funding and resources by servicing a wider customer base must be considered vital.

Whilst it is necessary to assist local industry and to enable stability in local processing it must be recognised that a large proportion of fibre transformation takes place offshore. A global approach to technology adoption of product and processing innovations will maximise returns to all stakeholders by accessing the largest markets possible.

Collaboration with end of pipeline manufacturers to pull products through

Thirdly, the SAC has identified development of new consumer products as the highest priority and that this can only be achieved through collaboration with the garment, shoe and accessories industries with the CSIRO's primary role being the provision of enabling technology. In fact the Sector Plan Overview endorses the need to develop new consumer end products, however few CRPs currently address it.

The Committee is concerned that projects do not undergo a rigorous enough cost/benefit analysis before commitment. Further, it appears that technology adoption rates are low and that there is no objective methodology to measure the "success" of any particular project. The Committee believes that a significant number of the projects in this Sector Plan currently lack industry support which will lead to difficulties with commercialisation. Therefore, the value of R&D within this sector must be enhanced by ensuring that R&D outcomes have identified owners and adopters and that research activities are addressing identified industry concerns. The SAC therefore recommends the development of a full cost methodology for assessing the merits of a total project which includes commercialisation and technology transfer.



Margaret Moroney
Chair, Wool and Textiles Sector Advisory Committee

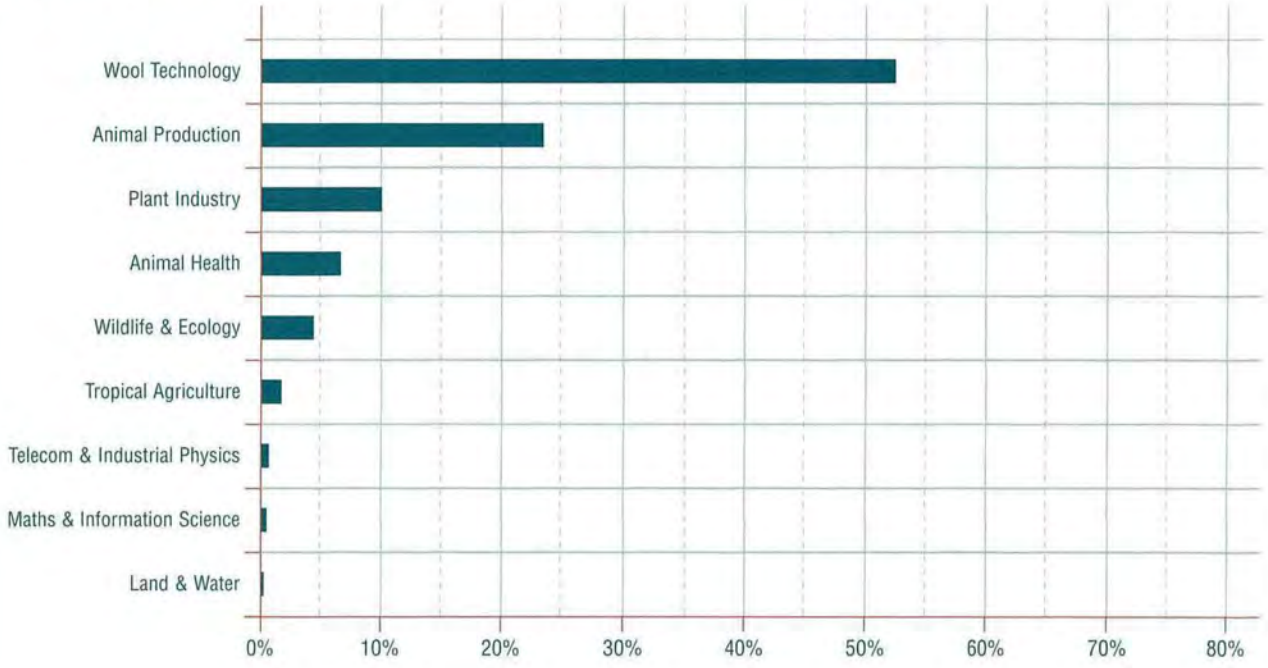
Wool and Textiles Sector Advisory Committee:

Margaret Moroney (Chair), Margaret Moroney Pty Ltd; *Ray Chapman*, COOGI Australia Pty Ltd; *Trevor Dawson*, Rocklea Spinning Mills Pty Ltd; *Guy Fitzhardinge*, Livestock Producer; *John Menzies*, Austanners; *David Ward*, Australian Wool Testing Authority Ltd; *John Blood*, Textile & Garment Consultant; *Bill Cook*, Wooltech; *Brian Fisher*, Australian Bureau of Agricultural & Resource Economics; *John Grant*, International Wool Secretariat Australia; *Andrew Vizard*, University of Melbourne

Wool and Textiles

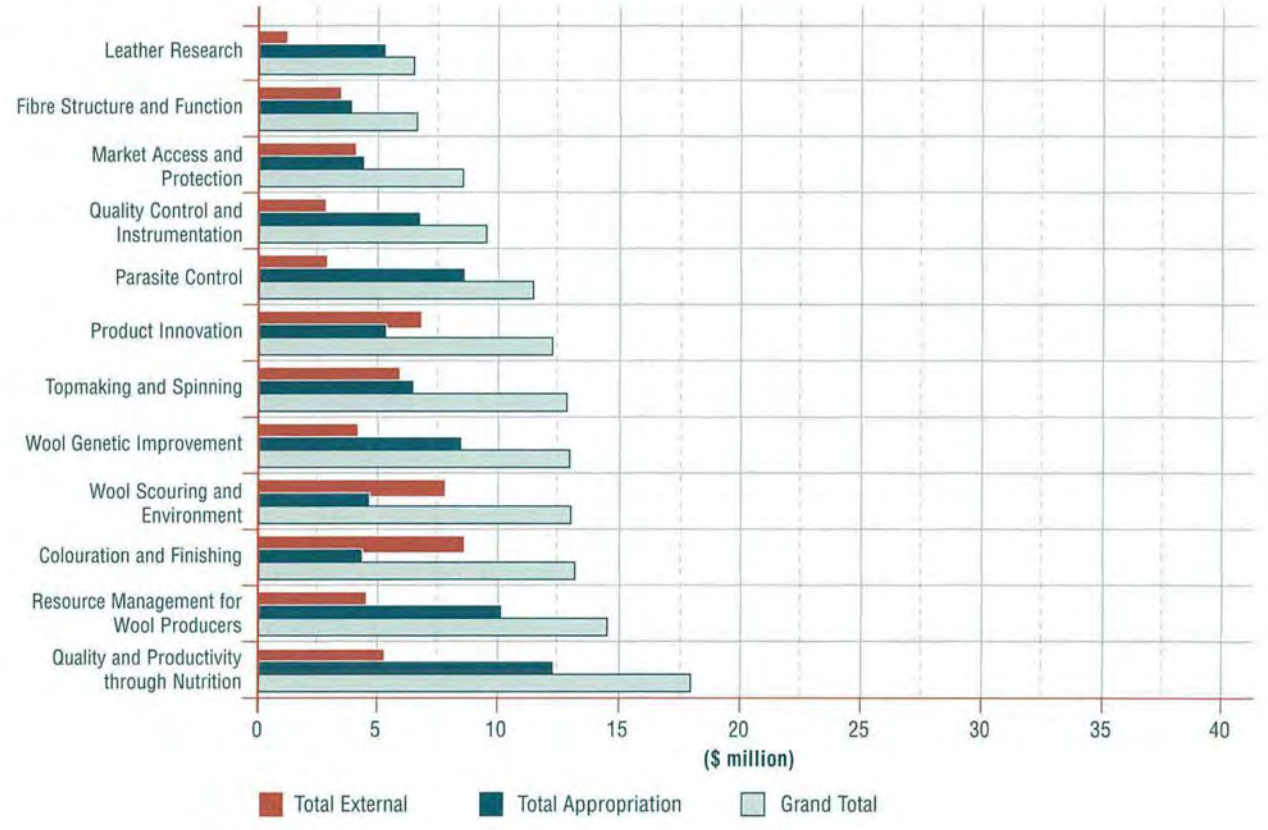
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $139.67 million)



Triennial Investment by Component

(Total Sector Investment $139.67 million)



Mission

To deliver research outcomes that facilitate the international competitiveness and environmental sustainability of Australia's wool and textiles sector.

Overview

Raw materials

Australia is the world's largest producer of wool and dominates international trading in apparel wool. However, there is strong competition from manmade fibres and cotton so that, despite Australia's position as a producer and exporter of fine wool, prices are determined by the world textile fibre market.

Cotton is the most commonly used textile fibre occupying 48% of the world fibre market. Australia is now the fourth largest exporter of raw cotton. Cotton fibre production is addressed by CSIRO's Field Crops Sector. The Australian cotton textile industry is small by world standards, but it has established a reputation for high quality.

Australia is second only to the USA as an exporter of hides (2–3 million a year as raw hides, 5–6 million processed to the 'wet blue' stage). It is the largest exporter of sheepskins (30 million a year).

Value-adding

The products mentioned above are all significant earners of income but are exported largely in the unprocessed state. A number of technical, commercial and environmental considerations point to good prospects for domestic value-adding. For example, the conversion of all suitable greasy wool to top in Australia could increase export earnings by $2000 million. However, there is currently excess combing capacity worldwide and Australia has to compete with low-wage countries. Export earnings from local processing of cotton and of hides/skins/leather could double their current export earnings of $1,000 million each.

APEC has important, positive implications for this sector, as it does for agriculture generally, where Australia enjoys a number of natural advantages over its trading partners. On the other hand manufacturing and the industries that supply intermediate products to the manufacturers will experience difficulties as a result of increased competition from developing countries. This may have an effect on the textile sector for the same reason. It is already accepted that, to survive, the textile industries must focus on the development of high quality products for export and substantial progress in this direction has already been made. Again there is an opportunity to add value to the unique raw materials—wool, cotton and leather—that underpin this sector.

CSIRO's role

CSIRO is one of the few research organisations in the world that span the wool business system from pasture to final garment This is because Australia dominates international trade in fine wool used for apparel. Australia needs to invest in fine wool research in order to ensure that its special processing requirements can be met by a global industry that is increasingly focused on fibre blends and manmade fibres.

Integration and restructuring of the production and processing chains are essential to the exploitation of research outcomes. Tools for quality management, and their application, will play a key role. However, the decline in extension services to the agricultural industries through State departments of agriculture and technical services to the wool textile industries through the International Wool Secretariat (IWS) is leading to strong pressure on CSIRO to change the balance of its research to include more short-term projects and consulting activities. In the past CSIRO has been discouraged from involvement in such activities especially in the textile area.

On the supply side wool and cotton are very often only one component of farm production, and there is a variety of agencies, research organisations and industries, both here and abroad, with whom fruitful collaborations can be established to advance knowledge and facilitate the implementation of research outcomes. There are good prospects for improvement in the quality and efficiency of wool and leather production and in meeting and overcoming serious environmental threats to the production and processing base.

The production and processing of wool has been a major thrust of CSIRO research for the agribusiness sector of Australian industry and financial support from the IWS remains the largest single source of external funding for the whole of CSIRO. The sector also includes the hides, skins and leather industry.

Research into the processing of cotton and manmade fibres is not being undertaken at present and will focus initially on blends of these fibres with wool. There have been marked changes in textile processing in the cotton and manmade fibre industries due to competition between them. The cotton industry recognised the advantages of blends with manmade fibres and the

mutual benefits to be gained by such a policy. The wool industry stands to gain much through closer interaction with the cotton industry and appropriately qualified staff will be needed to fully capitalise on this opportunity .

Customers

IWS has been the major contributor of research funds to the sector, providing approximately $30 million a year over the period 1994–95 to 1996–97. IWS has developed an extensive international network of branches and regional centres to facilitate its technical and commercial activities. CSIRO and IWS have entered into a strategic alliance in order to develop a joint approach to the planning and execution of research and development, together with the effective delivery of outcomes to the global textile industry.

Research funding, provided mainly by the producers of natural fibres and the Australian Government through the Rural Industry Research Funds (RIRFs), is volatile because it is geared to prices paid. CSIRO needs to broaden its funding base, to buffer these variations and ensure that the primary beneficiaries of its research, many of whom are located offshore, make an appropriate contribution. The rapidly developing domestic markets of Asia provide an obvious target for these endeavours.

Major issues

This plan addresses the issues that the Sector Advisory Committee considers underpin the future prosperity of the sector, namely:

Issue 1: generation of new products that meet consumer requirements through the integration of innovative product technology, creative product development and marketing

Issue 2: greater productivity and improved quality throughout the entire business system

Issue 3: development of technologies to ensure environmental sustainability of wool and hide production and processing; and

Issue 4: encouragement of value-adding in Australia.

These issues call for inputs from a wide range of current research activities which are described in detail under the Component Research Plans (CRPs). While the focus of each CRP will be within one of these broad issues, there is obviously interaction between them. In particular, a number of the CRPs will encourage value-adding, which is highly dependent on government policies.

The sector advisory committee expects to refine the priorities within these areas during the triennium.

Major objectives and key potential outcomes

Current outcomes under CSIRO's major objectives are concerned only with the production and processing of wool and leather. Future activities will also involve the processing of cotton and manmade fibres. Strategies for this expansion will be developed with the sector advisory committee during 1997.

Product innovation (issue 1)

Objective

The primary objective for the future of Australian natural fibre production and for its textile industry is to develop exciting new products in a cost effective and environmentally sustainable way.

In general the identification of opportunities for product innovation comes from industry either directly or through a facilitating agency such as the IWS. The role of CSIRO is to work in collaboration with the industry to provide enabling technology together with quality assurance and product performance testing.

Outcomes

- the development of natural-fibre-containing products that exhibit the aesthetic and performance characteristics demanded by consumers, through better quality new processes and fibre modification
- strategic alliances and collaborations in the local and Asian textile markets
- closer linkages and working relationships with the Australian textile industry.

Fibre processing (issue 2)

Objective

More efficient processing of natural fibres, including blends with manmade fibres, through an understanding of basic physical mechanisms.

Outcomes

- low entanglement scouring, providing better yields in topmaking
- major new process modifications for the very high speed worsted card
- continuous processing technology for topmaking
- 20% increase in spinning productivity on ring frames
- weaveable singles yarns
- improved quality in bovine finished leather.

Quality improvement (issue 2)

Objective

Apply objective measurement, quality management and information technology to reduce the length and complexity of the natural fibre business systems, to improve product quality and to facilitate the transmission of market signals throughout the business system.

Outcomes

- major contribution to the introduction of computer selling (sale by description) and consequent rationalisation of commerce in raw wool
- measurement tools for characteristics such as style (raw wool), bundle strength (tops), contamination (yarns) and pressing performance (fabrics)
- processing prediction and genetic selection systems based on new measurements.

Raw material production (issue 2)

Objective

More efficient production of wool, hides and skins through genetic engineering of animals and plants, disease and pest control, nutrition, and pasture and whole farm management.

Outcomes

- efficient production of high quality wool
- increased resistance of animals to disease
- increased resistance of plants to disease and herbicides, and improved utilisation of fertiliser
- improved nutritional quality of pastures.

Environmentally sustainable production and processing (issue 3)

Objective

Overcome major environmental threats to the production and processing of natural fibres and reduce community concerns.

Outcomes

- new, environmentally-friendly, chemical processes for scouring, colouring, tanning and fabric finishing
- more sustainable productivity of soils, pastures and animals
- reduced reliance on chemical inputs to control major sheep parasites
- pasture plant species adapted to difficult production environments
- decision support systems that will assist managers making decisions about wool production systems.

Value-adding (issue 4)

Objective

Assist local industries to increase the level of processing in Australia by encouraging them to adopt the latest techniques in early-stage processing and to provide a base for the trialing of new CSIRO technologies prior to their global release, thereby gaining valuable lead time over competitors.

Outcomes

- highly efficient topmaking operations based on latest CSIRO developments in raw wool and top specification, process prediction, scouring, effluent treatment and continuous physical processing
- a major portion of the wool clip converted to the top stage in Australia by 2010.

Customers, technology transfer and commercialisation; marketing and communication

Marketing and communication activities are integral to effective technology transfer. Customers are defined as people who pay money for the outcomes of research and make use of it. There may be many other beneficiaries who are classified as users.

Customers

- IWS and other RIRFs
- processors of wool, cotton, hides skins and leather, and manmade fibres
- textile machinery manufacturers
- chemical industries
- scientific instrument makers
- pharmaceutical and agricultural chemicals industries
- Federal Government departments, agencies and committees (for policy issues)
- producer and processor industry groups.

Technology transfer and commercialisation

Technology transfer and commercialisation issues are developed with customers before initiation of research, with emphasis on planning and portfolio management. There is early involvement of industrial partners as members of steering committees managing all phases of the research.

Wool and Textiles

Ownership of the research and the intellectual property generated is determined by relative financial contributions. Patents and licensing arrangements are used to gain commitment of the parties, to maximise speed and level of uptake by industry, and to generate royalties and licence fees from the beneficiaries of the research.

Development of CSIRO's R&D capacity

- CSIRO has unique pilot plant facilities in wool and leather research. These facilities will be expanded and staff training initiated to focus on product development.
- CSIRO has skills in the processing of cotton but will have to install new equipment for the physical processing of cotton and blends of wool, cotton and manmade fibres.
- CSIRO has a unique resource in its national biocontainment facility with a multidisciplinary team capable of tackling all animal health issues that impact on wool production and trade. An animal facility is under construction that can be used for large-scale experiments involving recombinant organisms.
- Existing skills in image analysis, physical optics and computer science will be enhanced for quality improvement programs.
- Biomolecular and genetic engineering technologies are being developed for further research into animal and plant productivity, sustainability, and disease control and prevention.

Performance and evaluation measures

General performance and evaluation measures which will be applied include:

- successful technology transfer and commercialisation activities
  - — customer satisfaction
  - — level of external funding
  - — repeat business
  - — level of consulting activities
- contracts and agreements concluded
- projects completed on time
- training and extension
- publications, reports patents, lectures, seminars and conferences
- positions held in public and private agencies, associations and professional bodies, serving private business, public facilities and government departments
- public recognition and awards.

Sector coordinator

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Divisional participation

Wool Technology, Animal Production, Animal Health, Plant Industry, Wildlife and Ecology, Tropical Agriculture, Telecommunications and Industrial Physics, Mathematical and Information Sciences, Land and Water.

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	26.1	27.4	28.2
External funding	18.4	19.3	20.2
TOTAL	**44.6**	**46.7**	**48.4**
External/total ratio	41%	41%	42%

Biodiversity

Sector Foreword

The sector planning process has provided a valuable opportunity for CSIRO, in concert with some of the Biodiversity Sector's significant stakeholders, to review strategic directions, priorities and resource allocations.

The staff of the Divisions approached the task with enthusiasm and commitment and the thanks of all Committee members go to them in this regard.

Within a relatively short time frame, the process sought to distil what contribution CSIRO was uniquely placed to contribute to biodiversity conservation. There was broad agreement that the Sector should focus at the national level and ensure that internal structures and programs were designed, in such a way to facilitate greater integration between Sectors, ensuring that biodiversity is adequately considered in the ESD framework.

Significant emphasis was placed on ensuring that the work of the Sector underpins resource decisions and is proactively able to shape as well as respond to the Government's long term policy agenda. This reflected the Committee's view that CSIRO's work should contribute to policy debates and therein make a more direct linkage between scientific endeavour and well informed policy outcomes.

It was acknowledged that CSIRO was well placed to contribute to the development of meaningful performance indicators for biodiversity conservation, supported by effective monitoring regimes.

While the Committee sought to achieve a stronger and more client focus within the Sector's marketing and research endeavours, it was agreed that the Sector must be acknowledged to contain an ongoing commitment to so-called "public good" endeavours that would be less likely to attract external funding.

Robyn Kruk
Chair, Biodiversity Sector Advisory Committee

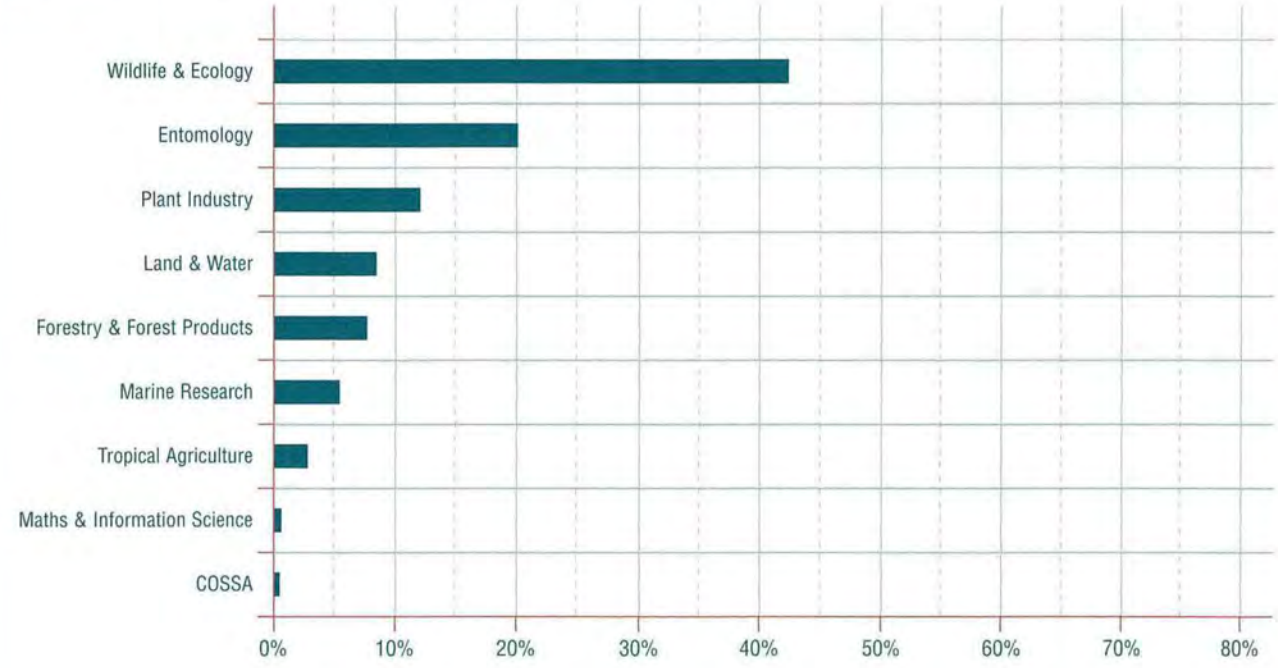
Biodiversity Sector Advisory Committee:

Robyn Kruk (Chair), NSW National Parks & Wildlife Service; *Malcolm Forbes*, Environment Australia; *Colin Griffiths*, Environment Australia; *Henry Nix*, Australian National University; *Jim Downey*, Australian Conservation Foundation; *Des Griffin*, Australian Museum; *Pauline Ladiges*, University of Melbourne; *Pamela Sayers*, Tourism Council of Australia

Biodiversity

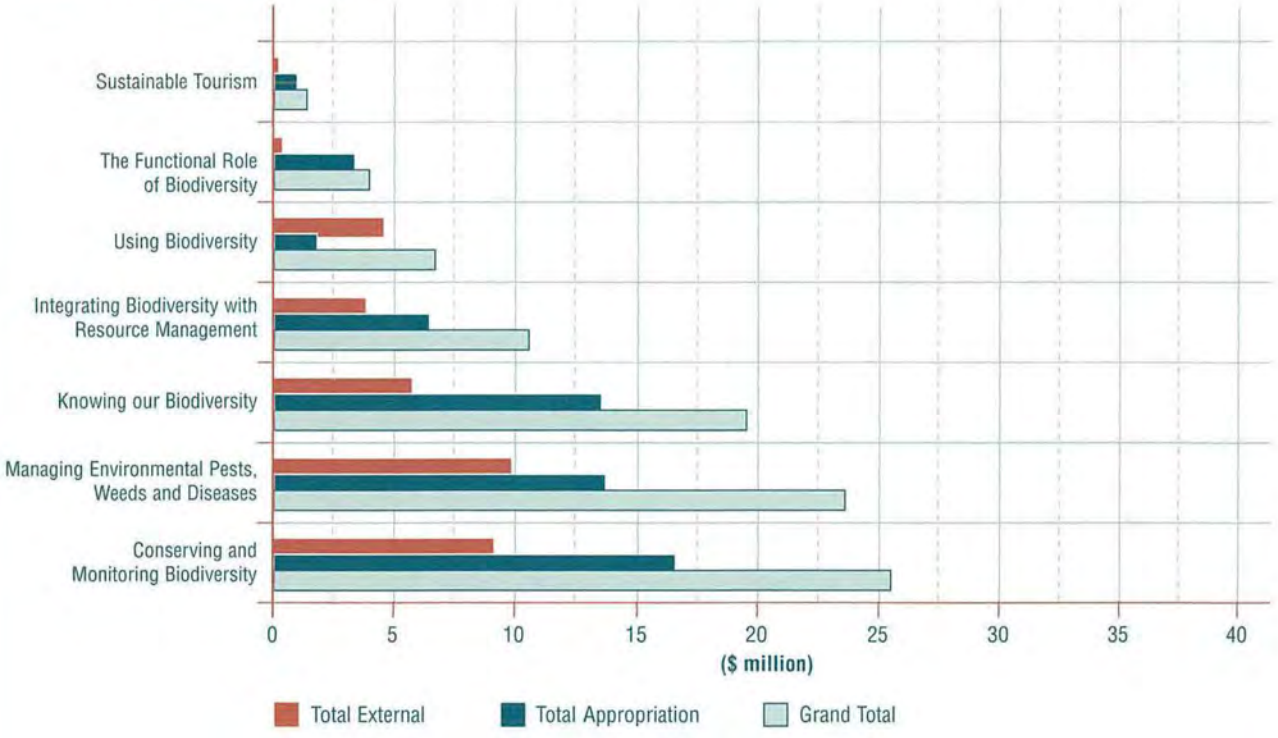
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $91.81 million)



Triennial Investment by Component

(Total Sector Investment $91.81 million)



'An environment rich in biological diversity offers the broadest array of options for sustainable economic activity, for nurturing human welfare and for adapting to change.'

National Strategy for the Conservation of Australia's Biological Diversity

Mission

To contribute to Australia's future by providing understanding which allows the sustainable use of biodiversity and other resources.

Overview

Issues

Australia's rich and largely unique biodiversity is one of its key natural resources—with one million species, Australia is one of the biologically richest countries in the world. Many important industries, such as tourism, agriculture, forestry and fisheries depend directly upon biodiversity.

The major issue for biodiversity in Australia is achieving compatible use and conservation of its resources. Direct uses, like harvesting native forests or grazing native rangelands, and the changes caused by other land uses, like clearing vegetation, altering river flows or controlling fire, impact on biodiversity stocks. Because Australia's flora and fauna have been isolated for a long time from the rest of the world, they are unusually susceptible to the effects of invasive species. Stopping the steep rate of decline in biodiversity due to alien pests, weeds and diseases is therefore another major issue. It is not enough just to conserve biodiversity in reserves—all land users must contribute to this vital task.

Australia has recognised that action is needed to address these major issues. It has made a commitment under the International Convention on Biological Diversity to address biodiversity conservation and has developed a national strategy to implement it.

CSIRO's challenge is to help Australia identify the major research issues and priorities underlying the conservation and use of biodiversity, and to provide the required research results in concert with other research providers. Biodiversity issues, strategies and actions are well articulated in Australia. As well as the National Strategy for the Conservation of Biological Diversity and the international convention, the following policies and programs also provide important leads for determining where Australia should put its biodiversity research effort:

- State of the Environment reports (national, State and local government)
- national tourism strategies
- National Weeds Strategy
- the Natural Heritage Trust (includes the National Vegetation Initiative, the National Land and Water Audit and the National Reserve System).

As well as providing general research direction, these policies and programs also drive specific demands for CSIRO's biodiversity research. Policy developers need technical advice to underpin new policies; those implementing the policies need methodologies, and policy makers need evaluation techniques. CSIRO also has a role in contributing to the development of policy agendas. As biodiversity is predominantly a public good, its protection is heavily dependent on government policy. This sector therefore has particularly strong links with government.

Benefits

Benefits to Australia of addressing these issues are:

- ***Economic*** benefits from the improved sustainability of natural resource-based industries, including tourism, from the development of new industries based on biodiversity and from reduced costs of combating weed, pest and disease problems.
- ***Social*** benefits from satisfying national and international demands for conservation as a legitimate social goal, from providing more income options for rural societies and from maintaining resource use options for future generations.
- ***Environmental*** benefits from ecosystems which are resilient to forces of change, whether human or naturally induced.

Benefits from CSIRO's research in this sector also flow to neighbouring countries through collaborative projects aimed at developing their capabilities and through the application of CSIRO technologies.

CSIRO's role

CSIRO carries out about a third of Australia's total research effort on biodiversity. Other key providers are the research arms of State agencies, the herbaria, museums, universities and CRCs. The CSIRO focus in the sector is on issues which require strategic research, multidisciplinary approaches or a national perspective. There is often collaboration with the other providers, bringing together the specialised skills and mandates of all types of organisations. CSIRO will widen and strengthen these links in the next three years to assist

Australia in developing a more cohesive approach to all its biodiversity research.

CSIRO is also responsible for the maintenance of legislated national collections of plants, insects and wildlife, as well as a comprehensive fish collection.

Approach

Two criteria were used to formulate the composition of the sector's research:

- the priorities identified in the national strategy and
- CSIRO's capabilities relative to other research providers.

These led to the following structure:

1. Knowing Australia's biodiversity ($6m, 31% externally funded, 1997–98)
2. The functional role of biodiversity ($1m, 20%)
3. Using Australia's biodiversity ($2m, 72%)
4. Sustainable tourism ($0.5m, 17%)
5. Conserving and monitoring biodiversity ($8m, 33%)
6. Integrating biodiversity with resource management ($3m, 38%)
7. Managing environmental pests, weeds and diseases ($8m, 42%).

For strategic reasons, these seven components are not equal in size. Components 1, 5 and 7 are the largest, reflecting research areas which are well established. Components 2, 3, 4 and 6 are smaller, reflecting their status as newer research areas which need to expand (4) or are particularly important areas requiring focus (2, 3 and 6). Components 3, 6 and 7 are expected to earn a higher proportion of external funds than the others, with component 4 particularly targeted to build a new client base.

The balance between components is considered appropriate for the next three years. It has resulted from an on-going process of prioritising research in divisions, including the Biodiversity Multidivisional Program (MDP), and no major shifts between components are planned in the next three years. However shifts between projects within components are anticipated as the diverse project mix (an average of four divisions are involved in each component) begins to focus more cohesively on component objectives.

Links with other sectors

At the project level, more than 40% of projects are shared between the Biodiversity Sector and other sectors. The closest link is with Land and Water, but both other environment sectors and a number of production sectors share research with this sector. These project-level links will ensure that outcomes of Biodiversity Sector research are closely integrated with outcomes for other sectors.

The link with the Land and Water Sector is particularly strong for component 6, which is informally linked with its component 'Resource use and society' through overlapping component leadership and research themes. Biodiversity research is also located in the conservation component of the Marine Sector. Informal links will be developed with this component to ensure a cohesive approach, both internally and externally.

Consultation

The Biodiversity Sector Advisory Committee was consulted in developing the future directions for this sector, and has commented on and finally endorsed this plan. Consultation with major stakeholders also occurred during the existence of the Biodiversity MDP, now incorporated into this sector; this too influenced the development of the research program.

Major objectives and outcomes

Major objectives for each component are embodied in their expanded titles. Key outcomes for each are:

1. Knowing Australia's biodiversity: facilitating access and exchange of information

   Outcome: *High quality information about Australia's biodiversity widely available in easy-to-access forms.*

2. The functional role of biodiversity in ecosystems

   Outcome: *Land management practices which optimise the balance between production, the conservation of biodiversity and the maintenance of ecosystem function.*

3. Using Australia's biodiversity: identifying and developing innovative uses

   Outcome: *New or improved products or industries based on Australian biodiversity.*

4. Sustainable tourism

   Outcome: *Maximisation of sustainable economic, environmental and social benefits for the tourism industry of Australia while minimising detrimental impacts.*

5. Conserving and monitoring biodiversity: principles and applications of conservation biology

   Outcome: *Better targeted and cost-efficient solutions to biodiversity conservation problems.*

6. Integrating biodiversity with resource management

   Outcome: *Better biodiversity conservation through integration of biodiversity considerations into decision*

making about the use of natural resources, especially at regional and national scales.

7. Managing environmental pests, weeds and diseases
   Outcome: *Environmentally sensitive control of key pest organisms threatening Australia's biodiversity.*

Customers, technology transfer and commercialisation

This sector is supported by a very wide range of customers who are predominantly public sector or who represent private sector interests through coordinating bodies such as the R&D corporations. A selection of recent clients includes:

- Environment Australia
- Rural Industries Research and Development Corporation
- NSW National Parks and Wildlife Service
- ACT Electricity and Water
- Australian Centre for International Agriculture Research
- Global Environment Facility.

The large number of clients reflects the widespread demand for biodiversity-related research and expertise. While this makes it difficult to develop a cohesive client strategy, it reflects the nature of biodiversity: spread across the landscape, affecting many industries and communities, within the mandate of all levels of government.

Nevertheless, CSIRO's strategic and national focus means that CSIRO focuses on clients and issues where research solutions will have major impact. For example, research on indicators of biodiversity will have widespread impact as all levels of government are required to prepare regular State of Environment reports; Environment Australia is a past and prospective client for this work. CSIRO would not normally be involved in addressing local conservation issues, which State agencies and community groups are better placed to do.

Technology transfer is accomplished in this sector by developing close relationships with clients (for externally funded research) and/or stakeholders (for CSIRO funded research), as early as possible in the research cycle. On-going relationships with major clients are fostered through wide scientist involvement in technical and advisory committees; this involvement serves both marketing and technology transfer purposes. Opportunities to participate in policy-making activities of agencies are used to ensure that policy is soundly based technically, research agendas are well guided and scientists are aware of policy market needs.

Decision support software is growing in importance as a technology transfer medium and the sector plans to develop new packages in the next triennium in components 1, 4, 5 and 6.

CSIRO will manage its commercial business for this sector, including the protection of its intellectual property, through its constituent divisions.

Marketing and communication

Marketing of the broad range of skills will be carried out by constituent divisions, but with a sector rather than a divisional focus. This will require good internal communication, so that every constituent division can present a sector view to an outside audience and channel prospective work to appropriate divisions in CSIRO. Regular component meetings will foster this process and CSIRO will develop web material to support internal communication, and appoint key scientists as account managers with major clients.

In established markets, CSIRO's past record and reputation is an important marketing tool, which will be sustained by ensuring the quality of its contract output. Particularly in the newer areas of research in Components 4 and 6 active marketing to new clients is planned.

Public education is particularly important in this sector and divisions will continue participating in field days, issuing press releases, publishing material and contributing to appropriate public events. Sector divisions will support continuation of ECOS and the relevant Australian scientific journals published by CSIRO.

Development of CSIRO's R&D capacity

The major characteristic of this sector in the future will be a tension between the growing demand for biodiversity conservation, both for its social and economic benefits, and rising global and national demands for using natural resources. CSIRO's existing capacities, now better focused in the seven multi-disciplinary components, are mostly appropriate for meeting the market needs of the next few years. Attention will be paid to developing taxonomic skills for groups important in Australia, and expanding into new technologies in molecular systematics. New socioeconomics skills, particularly required in

components 4 and 6, will be acquired by a mix of collaboration and limited, selective appointment of staff.

Some opportunities exist in the application of new technologies to research problems in this sector. Developments in biotechnology have special application to pest and weed biocontrol methods. Developments in information technology will be applied to improving access to the vast amounts of taxonomic knowledge CSIRO holds and to complex systems research.

Performance and evaluation measures

Key success measures in this sector relate to the uptake of research results, its subsequent impact on biodiversity, and impact on the scientific community. Due to project sharing across sectors, the corporate performance indicators collated on a divisional basis will be difficult to cross-calculate for this sector.

Therefore this sector proposes to assess its performance at biennial review and planning meetings of individual components. Small review panels will be constituted from the sector committee and the sector advisory committee for this purpose. Review outcomes will be shared with participating divisions, which will undertake to consider and act on review recommendations.

Divisions will remain responsible for monitoring progress of externally-funded research against contracted milestones.

Sector Coordinator

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Divisional and other participation

Entomology (17.6 EFT), Forestry and Forest Products (7.6 EFT), Land and Water (12.8 EFT), Marine Research (0.6 EFT), Mathematical and Information Sciences (2.3 EFT), Plant Industry (20.8 EFT), Tropical Agriculture (7.0 EFT), Wildlife and Ecology (51.1 EFT), COSSA (1.2 EFT). CRCs: Freshwater Ecology, Vertebrate Biocontrol, Tropical Savannas, Tropical Rainforest Ecology and Management, Weed Management Systems, and Soil and Land Management. Australian Centre for Plant Biodiversity Research.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	18.6	19.1	19.5
External funding	11.2	11.5	11.9
TOTAL*	**29.8**	**30.6**	**31.4**
External/total ratio	38%	38%	38%

*Includes $0.16m for biometrics contribution, not allocated to components.

Climate and Atmosphere

Sector Foreword

On behalf of the Climate and Atmosphere Sector Advisory Committee I am writing to offer endorsement of CSIRO's Climate and Atmosphere Sector Plan. Key elements of the Plan which the Committee strongly supports are:

- maintenance of a strategic research base
- integration of a wide range of disciplinary expertise
- engagement of a broad range of stakeholders including industry, government and the community
- the independence of CSIRO as a source of expertise and provider of advice, and
- a clear focus on the issues of climate change, climate variability and air quality which are the major issues within the Sector of concern to Australia.

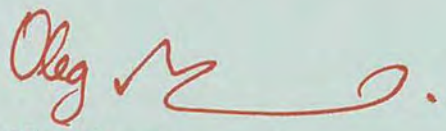
The Plan addresses the Messages and Challenges of the Strategic Research Directions document and in particular indicates a clear shift of effort towards air quality and climate impacts issues.

The Committee is keen to provide ongoing support to CSIRO through the Climate and Atmosphere Sector and is actively seeking appropriate ways to achieve this. It is presently taking steps with the Sector Coordinator to support and enhance marketing activities for the Sector.

My colleagues on the Sector Advisory Committee and I are greatly encouraged by the improved opportunity to participate in the Organisation's planning processes. We are keen to continue doing so.

With kind regards,

Yours sincerely,



Oleg Morozow

Chair, Climate and Atmosphere Sector Advisory Committee

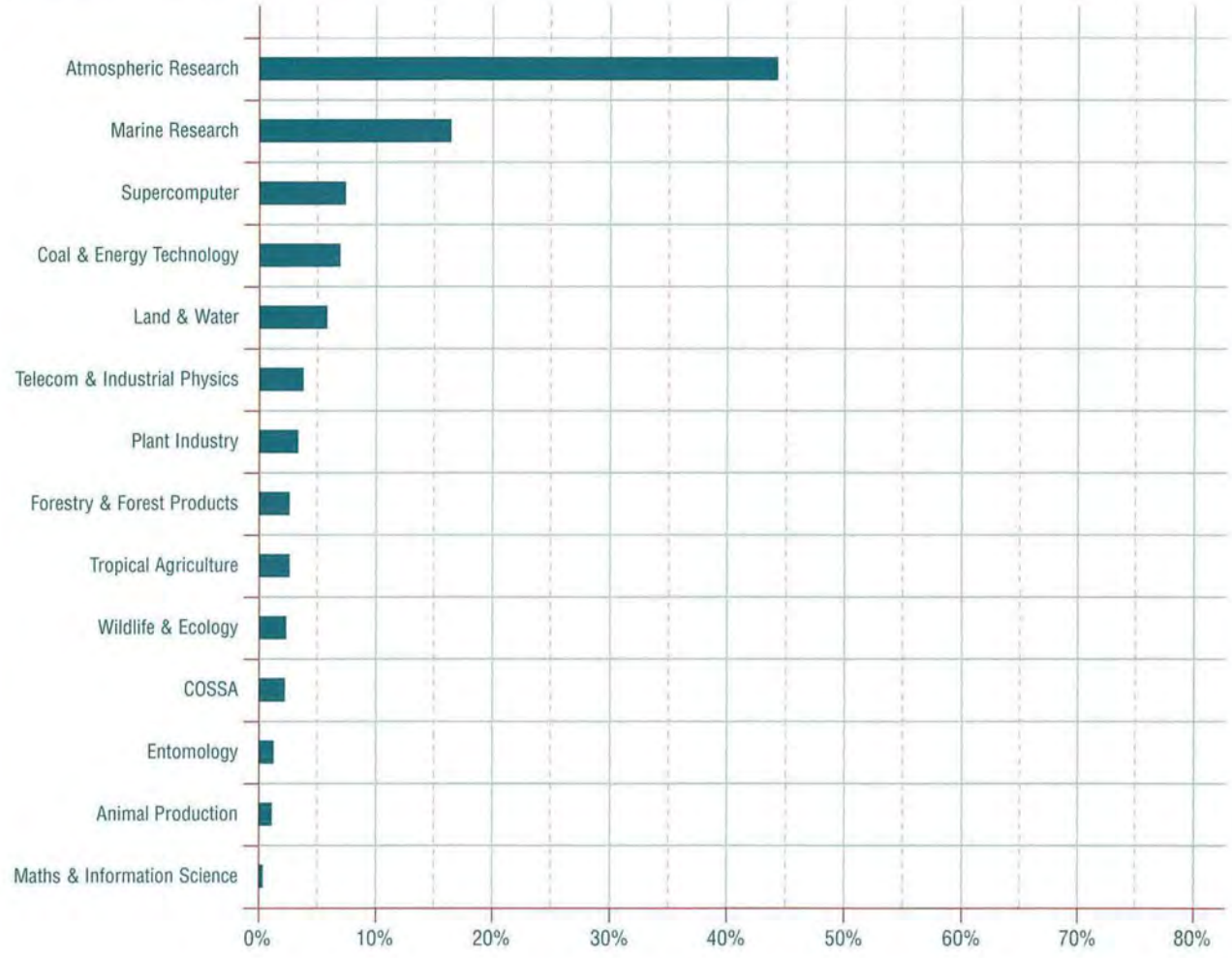
Climate and Atmosphere Sector Advisory Committee:

Oleg Morozow (Chair), Santos Ltd; *Doug Gauntlett*, Bureau of Meteorology; *Mark McKenzie*, NRMA Engineering & Environment; *Tom Fenwick*, Qld Dept of Natural Resources; *Stephen Corbett*, NSW Health; *Ros Taplin*, Macquarie University; *Michael Rae*, World Wide Fund for Nature; *Ian Carruthers*, Environment Australia; *Peter Scaife*, BHP Research Laboratories.

Climate and Atmosphere

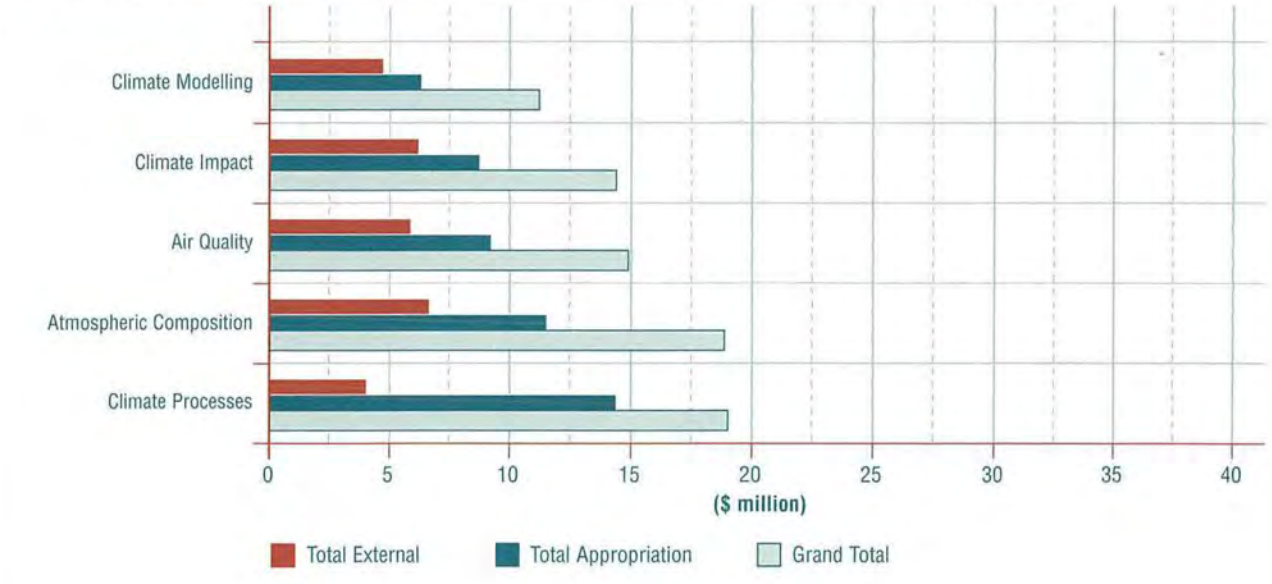
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $83.90 million)



Triennial Investment by Component

(Total Sector Investment $83.90 million, including $6.2 million for supercomputing not shown in the Component costings below)



Climate and Atmosphere

Mission

To carry out and apply research that will contribute to the sustainable management of our atmosphere and of those parts of our economy and community that are sensitive to the climate system.

Overview

Issues

Climate and Atmosphere Sector research is primarily in the category of 'public good, national interest'. CSIRO's role complements the roles of the Bureau of Meteorology, of the State environmental protection agencies (all of which have an operational focus) and of universities (which focus on fundamental research and teaching).

CSIRO places a strong emphasis on strategic research, targeted both for direct users and for policy development to applications in air quality, climate change and climate variability. It is by far the largest contributor of R&D in the sector Australia-wide.

R&D in this sector is highly integrated, because of the complexity of the climate system and the multidisciplinary nature of the problems under investigation. International links and collaboration are extremely important, given the global dimension of the climate system and the global nature of many key environmental issues of concern to Australia.

Value

CSIRO's research in this sector will continue to provide outcomes in support of the development of policy at local, regional, national and international levels, in support of infrastructure planning and in support of monitoring, observation and assessment of the atmospheric environment.

Industry benefits directly from CSIRO's capacity to measure, analyse and predict the environmental impacts of production, particularly in unusual, difficult or peculiarly Australian circumstances. Industry also benefits from technical advice on options for responding to government policy (for example under the Greenhouse Challenge Program) and from decision-support systems aimed at sustainable production under Australia's highly variable climatic conditions.

Government, industry and the community benefit from an independent source of scientific advice and expertise, with both a local focus and very strong international links.

Strategic R&D carried out for the sector is essential to achieving successful applications, as neither the research nor the application is 'off the shelf'. CSIRO is the only organisation in Australia with the breadth of expertise to maintain this research. In its absence it is unlikely that the research program would be carried out by others. Australia would have to rely increasingly on expertise from overseas that is not tailored to Australia's unique climate, demographics, soils and vegetation, and its position in the Southern Hemisphere.

Strategy

The keys to CSIRO's success in the sector are the depth and breadth of its strategic research base, its ability to integrate multidisciplinary skills across a large number of divisions and the close interactions between the strategic research and a wide range of applications. The successful Multi-divisional Programs (MDPs) on Climate Change, Climate Variability and Impacts, and Air Quality have set the framework for this integration on which the sector aims to build.

It is impossible (and undesirable) to completely separate core research from applications. Nevertheless, the structure adopted for the sector focuses much of the core research in three segments (Atmospheric Composition, Climate Processes and Climate Modelling). For the remaining two segments (Air Quality and Climate Impact), the balance is towards applications. There is however, a strong interaction between all five segments.

There is a need to maintain a strong core research base. The trend in stakeholder interests, the outcomes of the Outlook Forum, and the assessment of strategic research directions, support a shift of effort towards air quality and climate impacts. This is reflected in the financial projections for the sector.

Because the sphere of interest of the sector extends beyond its boundaries (and in particular overlaps a number of the production sectors), there is value in retaining the coordinating role of the MDPs. New links are being forged with the Mineral Processing and Metal Production Sector.

Strategic partnerships focused on atmospheric and climate science agencies (Bureau of Meteorology, Antarctic Division, CRCs) are essential and will continue to be fostered. Equally, links with other organisations such as the Australian Bureau of Agricultural and Resource Economics (ABARE), the Bureau of Resource Sciences (BRS) and the Queensland Department of Primary Industry (QDPI) will be used to provide social science and economic skills not carried within CSIRO.

Major objectives and key potential outcomes

To undertake strategic and applied research into the changing chemical composition of the atmosphere through:

- monitoring and interpretation of the composition of the background and regional atmosphere as part of a global observation program
- quantifying Australia's emissions (including the surrounding oceans) and uptake of greenhouse, ozone depleting and other trace gases
- the measurement of surface fluxes of greenhouse gases
- the development of a regional chemical transport model
- the determination of physical, chemical and biological factors controlling net uptake of carbon dioxide (CO_2) in the Southern Ocean and on the Australian continental land mass
- the prediction of long term trends in stratospheric ozone
- the development of non-ozone depleting fumigants.

To identify and study the critical interactions between the energy and hydrological cycles and the dynamics of the climate system, and to develop suitable representations of those processes through:

- parameterisations of atmospheric and ocean dynamics
- experimental and theoretical studies of clouds and radiation
- the development of cloud and aerosol parameterisations for use in limited area and global climate models
- the determination of land-air exchanges of CO_2, water and energy over Australia
- the determination of the Earth's radiation budget at the land surface
- the design and implementation of elements of an operational ocean observation system.

To develop and maintain a world class climate modelling facility and to apply it to predict climate change and climate variability through:

- the development of global climate models
- the development of a regional climate model
- ocean modelling
- the development of coupled ocean-atmosphere models
- studies of climate variability and climate change.

To assess the impact of climate change and climate variability on economic, social and environmental systems through:

- the development of regional estimates of climate change and variability
- tools for integrated climate impact assessment
- assessment of climatic and hydrological impacts on regional water supplies
- research on fire behaviour and forest management
- assessment of agricultural and terrestrial biological impacts of climate change and variability
- studies of the biological impacts of rising levels of CO_2
- assessment of ocean impacts of climate change and variability.

To develop and apply innovative tools for assessing the local and regional impact of pollutant emissions for planning and regulatory purposes through:

- a strategic scientific basis for the representation of the processes governing the concentration and transformation of air pollutants
- the development and application of computer-based air quality modelling systems
- the measurement and prediction of visibility-reducing aerosol and the causes and incidence of acid deposition
- integrated assessment of exposure to toxic volatile organic compounds in Australian cities.

Customers and technology transfer

Customers

There is a wide range of customers, stakeholders and collaborators. Paying customers include Department of Environment, Sport and Territories (DEST), State environment protection agencies, Bureau of Meteorology (BoM), Department of Industry, Science and Tourism (DIST), Department of Foreign Affairs and Trade (DFAT), Land and Water Resources R&D Corporation, Rural Industries R&D Corporation, resource industries, Forest and Wood Products R&D Corporation, Scantech, Water Authorities, Department of the Environment (USA), National Science Foundation (USA), World Meteorological Organisation, AusAid, Australian Centre for International Agricultural Research (ACIAR).

Technology transfer

Technology transfer will occur on many levels. Within the scientific community there will be mostly public domain dissemination of research through journals, conferences, reports and exchange of data sets. More widely there will be specific reporting to government and industry and through international forums such as the Inter-Governmental Panel on Climate Change (IPCC).

Commercialisation of numerical modelling applications will continue to take place through licensing agreements

that include training courses, and through the delivery of modelling systems under project contracts. Close collaboration with the corresponding program in the BoM will promote the operational uptake of new model developments.

Opportunities for commercialisation of new instrument technology (e.g. the volcanic ash detector, Airtrak and rainwater samplers) will continue to be pursued through commercial partnerships.

Transfer of model output to climate impact researchers will be facilitated by the liaison officer funded by DEST. The results of climate impact research will be transferred to end users via resource management decision support systems.

Development of CSIRO's R&D capacity

The existing skill base is very broad with expertise in theory, numerical modelling, field measurements and experimental plant science, and remote sensing. Maintenance of this capability is a divisional responsibility, but the Climate and Atmosphere Sector will promote coordination and sharing of resources.

There is a critical dependence on access to high performance computing (HPC). This will be met by the joint BoM/CSIRO HPC Centre currently under negotiation, by staged upgrades to supercomputing capacity in the Division of Atmospheric Research and the Antarctic CRC, and by corporate upgrades to divisional local area networks (LANs) and the CSIRO wide area network (WAN).

Continued access to a wide range of other facilities is essential. Some critical ones are:

- ships (RV *Franklin*, RV *Australis*)
- laboratories (for global atmospheric sampling, ice core extraction) and equipment (Phytotron, Airtrak and analytical chemistry facilities)
- pollutant dispersion models, limited area meteorological models, plant canopy and plant production models, the CSIRO climate model, the stratospheric chemical model and other local and regional models
- remote sensing satellites and ground stations
- advanced instruments for surface boundary-layer and cloud physics research
- advanced decision-support systems for management of rangelands, temperate pastures, whole farm systems and rural fires.

New capabilities planned include:

- new analysis technology for halocarbons, CO_2 and volatile organic compounds (VOCs)
- Temperature Gradient Tunnel facility
- 2-D model of global methane
- coupled dimethylsulfide and global climate models
- chemical transport model
- ocean carbon cycle model
- terrestrial carbon cycle model
- Southern Ocean tracer data set.

In the climate impact segment, the key requirement is for the integration of a research effort that is presently dispersed. Development of generic tools is planned.

There will be increased use of communication and information technology and of remote sensing technology.

Finally, a feature of the sector is the strong emphasis on international collaboration and exchange of information and technology. This will continue and is likely to increase.

Marketing and communication

Through marketing, CSIRO seeks to let stakeholders know what it has to offer—its capabilities and strengths and its areas of expertise. Equally, it seeks to understand the needs of its stakeholders. It addresses these objectives through a wide range of activities including:

- meetings and personal interactions with stakeholders at a range of levels
- surveys of stakeholder satisfaction with CSIRO's products and delivery
- briefings to stakeholders and presentations at key stakeholder forums
- training programs
- media releases and statements; pursuit of opportunities for mass media coverage and for placement of articles in key industry journals
- publication and distribution of scientific papers, conference papers, reports, newsletters, and promotional brochures
- open days and displays at appropriate events
- educational activities such as presentations to community groups, participation in school visits and tertiary lectures
- electronic dissemination of information through the Internet.

Climate and Atmosphere

These activities are divisional responsibilities and are widely dispersed at present, although there is effective coordination through MDPs. The challenge is to develop a sector focus. This will be achieved firstly through coordination of activities by increased networking of divisional marketing and communication staff. Secondly, dialogue with stakeholders at the sectoral level and opportunities for the injection of external marketing skills will be enhanced through briefing seminars convened and facilitated by the sector advisory committee.

Effective communication is integral to the success of the sector. The electronic mailing group set up for rapid information sharing between key sector staff offers a vehicle for news of advances and opportunities, feedback, and notification of forthcoming communication activities such as media releases.

Strong sharing of opportunities across divisions has been a feature in the past and will continue.

Performance and evaluation measures

Performance assessment is mainly a divisional responsibility. It ranges from formal reporting to the government, through review processes at various levels, to direct assessment of contract work by clients. Peer review is very important for international benchmarking of the science.

Performance criteria include:

Effective liaison with policy makers measured by

- the frequency of advice sought and given
- use of CSIRO's work in the policy making process by government, industry and the community.

Effective transfer of scientific advances to other experts measured by

- the number of collaborative projects
- adoption of CSIRO's advances in science and technology by other leading research teams in Australia and overseas.

Scientific excellence and advances measured by

- peer-reviewed publications
- international benchmarking through, for example, invitations to serve on scientific committees and to present keynote lectures at scientific meetings, and national and international awards
- acceptance of CSIRO research outcomes by other science teams.

Advances in measurement technology and model performance measured by

- international comparison projects.

Customer satisfaction measured by

- acceptance of advice
- contracts gained and completed
- repeat business.

Credibility as a source of independent and valued advice measured by

- breadth of stakeholder/customer profile
- demand for advice and briefings.

Recognition of national and international contributions measured by

- the use of results in national and international scientific assessments.

Leverage of international effort

- participation in international field experiments focused on the Australian region
- partnership in global observation networks
- partnership in international remote sensing observations.

Sector coordinator

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Divisional participation

Atmospheric Research, Marine Research, Land and Water, Coal and Energy Technology, Plant Industry, Telecommunications and Industrial Physics, Forestry and Forest Products, Wildlife and Ecology, Tropical Agriculture, Entomology, Mathematical and Information Sciences (Biometrics and COSSA/EOC), Animal Production.

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	18.5	18.8	19.0
External funding	9.0	9.3	9.4
TOTAL	**27.5**	**28.1**	**28.4**
External/total ratio	33%	33%	33%

Land and Water

Sector Foreword

The Land and Water Sector Advisory Committee has endorsed the Land and Water Sector Plan as an appropriate statement of the work to be undertaken and its prioritisation.

However, the Committee felt that the new Sector structure offers an opportunity to undertake a few "big, bold case studies", in which all the biophysical elements plus landcare and social issues could be drawn together, taking advantage of the once-off Telstra funded projects involving landholders/managers to constructively cooperate with scientists on major programs.

In order to achieve this, the Committee has suggested a day of strategic thinking and planning with the Sector early next year with a view to identifying a vision, objectives and strategies. This could then be fed into the Sector's corporate planning process.

The increased coordination and interaction which the Sector structure requires and encourages is a highly desirable feature of the new approach.

However, it must be overtly acknowledged that maintaining that level of effective coordination and communication within and between Sectors requires resources and that the provision of resources to undertake the task needs to be specifically identified in budgets and duty statements.

The Committee is concerned that unless this is done, the gains achieved to date may well be lost.

Effective linkage of CSIRO research capabilities to the agriculture sector likewise requires resources to assist the two-way communication required.

With the reduction in extension services by State Agriculture departments, a significant avenue of communication is closed, and this raises the issue of how research results can be provided widely to industry.

While it may not be cost effective or efficient for CSIRO to assume that development/extension role, CSIRO cannot ignore the need for alternative communication and delivery strategies to be developed, possibly through alliances with other groups, private enterprise etc.

It is mportant that research results and outcomes, where appropriate, be put in a form which is accessible to resource managers and which facilitates adoption of sustainable practices.

It is an issue to which we believe the Board should give considerable attention.

A related issue on which I will be writing to the Ministers for Primary Industries and Energy and Education and Training, the AVCC and the ARC, is the small number of rural sociologists in Australia, and the difficulties that causes in terms of encouraging changed agricultural practices.

The development of alliances, cooperative research etc. between CSIRO and rural sociologists will be, in the Committee's view, an essential ingredient of success in future programs relating to landscape management and change.

Wendy Craik
Chair, Land and Water Sector Advisory Committee

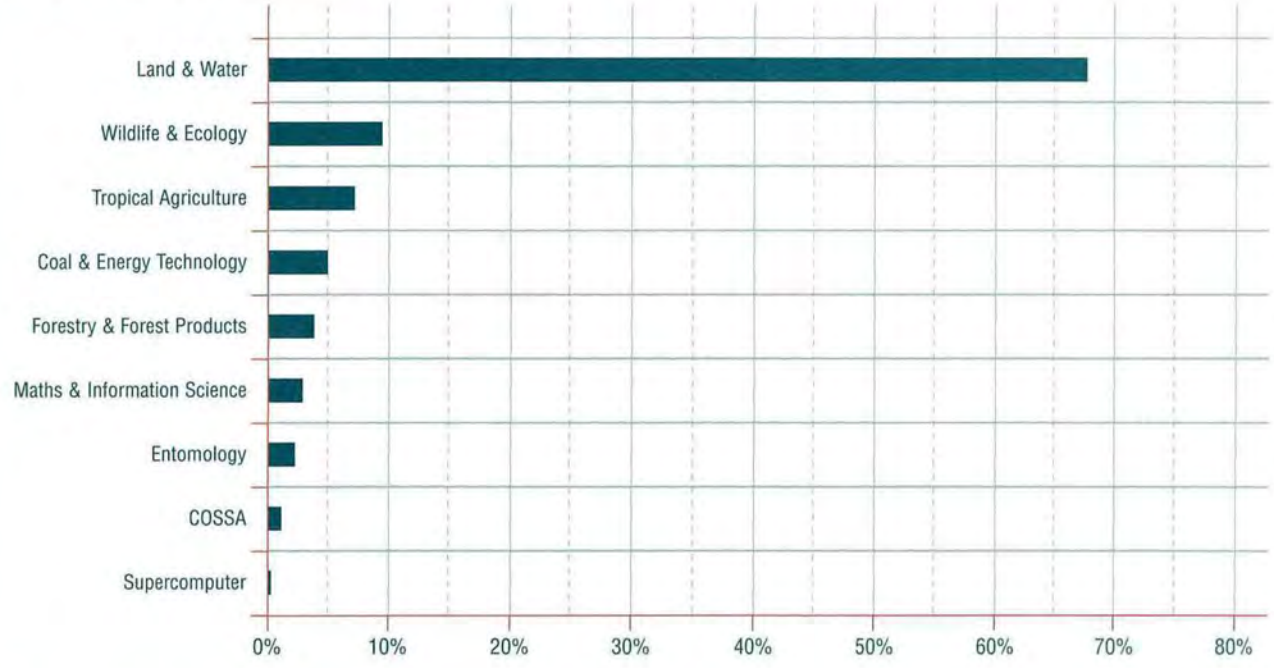
Land and Water Sector Advisory Committee:

Wendy Craik (Chair), National Farmers Federation; *Don Blackmore*, Murray Darling Basin Commission; *Geoff Gorrie*, Dept of Primary Industries & Energy; *Phil Price*, Land & Water Resources R&D Corp; *Kathryn Tayles*, CRA Ltd; *Joe Baker*, National Landcare Advisory Committee; *Andrew Campbell*, Environment Australia; *John Langford*, Water Services Association; *Graeme Robertson*, Agriculture WA.

Land and Water

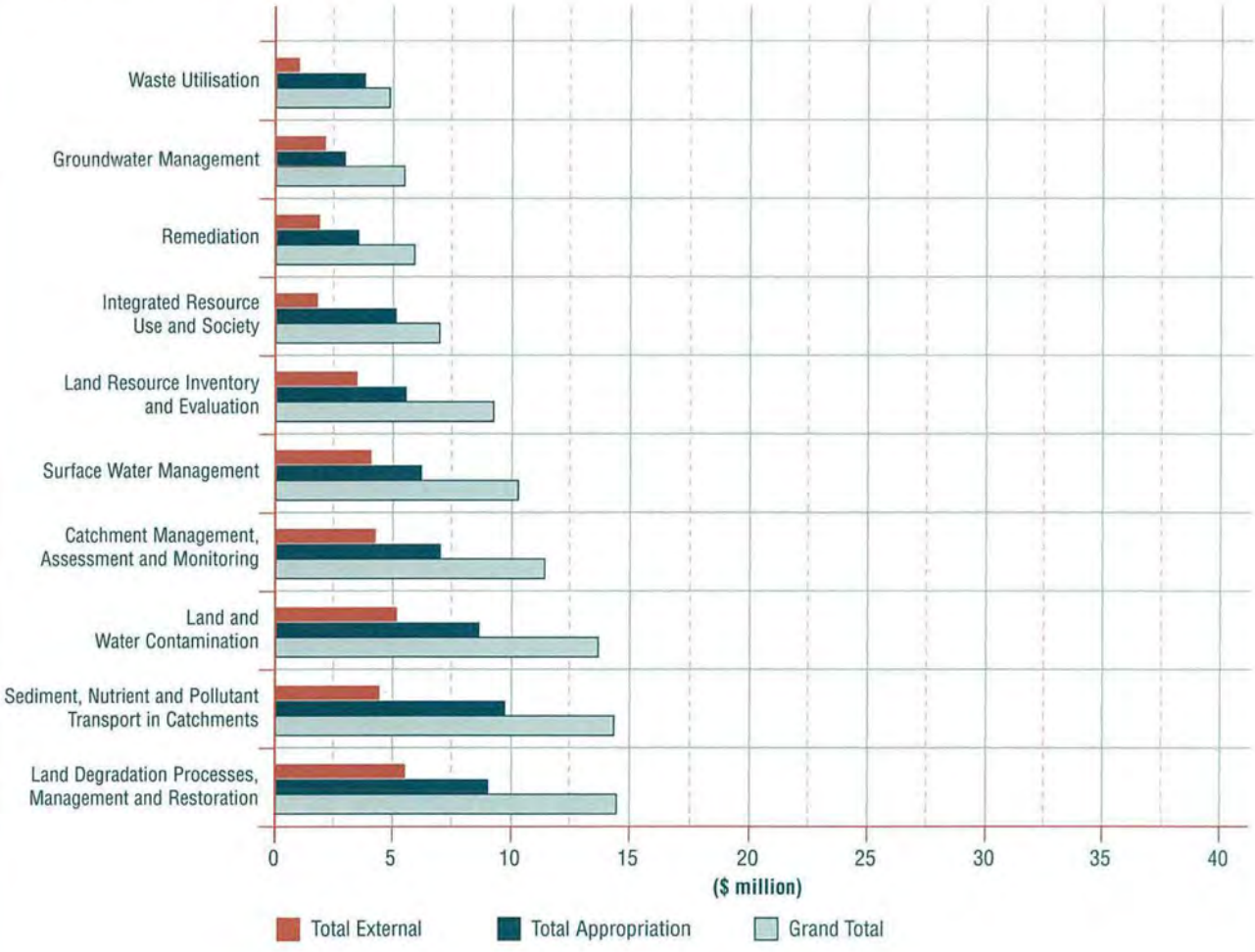
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $97.55 million)



Triennial Investment by Component

(Total Sector Investment $97.55 million)



Mission

Through world-class research, to deliver outcomes which promote the sustainable use of Australian land and water resources.

Overview

Australia's economic and social well-being depends on sustainable use of its fragile land and scarce water resources. This economic and social activity has had a profound impact on the quality of the land and water resource, with the consequence that many of Australia's communities and industries face resource and environmental problems. Rural, manufacturing, mining, energy and service industries must use these resources in an ecologically responsible way, meeting international quality assurance guidelines and providing quality products and environmental amenities to sustain Australia's quality of life and social well-being.

The passing of the Natural Heritage Trust Bill will generate opportunities for the sector through the National Land and Water Audit, Murray-Darling Basin 2001, the National Rivercare Initiative, the National Landcare Program and the National Wetlands program.

Major issues that face the Land and Water Sector, now and into the next century, include:

- **Large scale land and water management:** new methodologies are needed to link local actions to larger scale, catchment, and regional management of resources for sustainable systems.
- **Water quality and supply:** sound approaches are needed to ensure quality and security of water supply by developing better assessment procedures and 'whole system' management of processes that cause water resource degradation.
- **Regeneration of rural lands:** new land management and production systems are needed to match land use to land capability and climate, to increase productivity and to minimise degradation.
- **Decontamination of land and water:** driven by increasing regulation and public concern, remediation of soil and water will become more important and there is increased need to find beneficial uses for waste materials.
- **Technologies for measuring ecosystem health:** to halt damage to land and water, land users, local and regional catchment managers and policy developers require indicators of ecosystem health that are relevant to their decisions.
- **Resource use and society:** understanding social and economic links with ecologically sustainable development will provide new approaches to achieve outcomes that are just and equitable for society.

Approaches to managing many of the issues will be based on a detailed scientific understanding of the biophysical processes occurring in soil and water.

Potential value to Australia and CSIRO

The asset value of Australian land is $645 billion; that of water infrastructure is $82 billion. Ecologically sustainable development of Australian catchments and production of high quality food and fibre underpins $37 billion of rural exports and continued market access. Estimates of the cost of land and water degradation, measured as production losses alone, substantially exceed $1 billion each year. Prevention and remediation costs in mining and agriculture exceed $430 million each year; in tourism and recreation exceed $200 million, and there is a significant cost of remediation for high-value urban land.

CSIRO will work with government, industry and the community to help identify and monitor the resource. It will provide research for integrated and innovative science aimed at improving productivity, decreasing the incidence of degradation and reducing the cost of its remediation.

Overall strategies and approaches

CSIRO has a unique capacity to assemble teams to carry out integrated, multidisciplinary research into land and water resources. This capacity can link activities at all scales up to the catchment, the drainage basin, or the regional or national level. Part of the strategy will be to establish major case studies, in collaboration with other agencies, which will be completed over the period of the triennium. It is crucial to integrate current knowledge of soil, water, vegetation and atmospheric processes for catchments and large regions.

To prepare for the challenges of the 21st century, the sector strategies and approaches will use innovative science and technology to:

- maximise the conservation of soil and optimise the use of water
- improve the productivity and beneficial use of Australia's land and water resources
- participate in the national inventory of land and water resources
- find and implement indicators of ecosystem health
- understand key processes for land and water management

- facilitate the restoration and remediation of degraded land and water.

These overall strategies will be promoted by fostering collaborative links with other providers of environmental research, both within CSIRO and outside. They will require effective communication of research, the use by society of the research results, and their incorporation into resource management and national policy.

External consultations

In developing the Land and Water Sector Plan, consultations were held with the Sector Advisory Committee and the many advisory, consultant, government, industry and other groups that support and advise the divisions. These consultations were aimed at meeting the research and development needs of stakeholders. They also ensured effective liaison with RDCs, national, State, local government, environment and industry development agencies, CRCs, catchment management and Landcare groups.

Major objectives and key potential outcomes

CSIRO needs, urgently, to address a number of major issues to satisfy national and international concerns about the quality and sustainability of the land and water resource base. Among these issues, and some approaches to resolving them, are the following:

- **Assessment and monitoring of catchment condition:** proven catchment health indicators; assessment using remote sensing; better tools for water quality management; improved resource data; agroforestry practices for sustainable production.
- **Sediment, nutrient and pollutant transport in catchments:** reduced pollution of waterways by nutrients, toxicants and sediments; sustainable land use to minimise pollution; improved land use planning to minimise pollution.
- **Surface water resources and management:** improved prediction of the impact of human activities; advanced development platform for delivery of decision support; process-based models for improving the quality and increasing the quantity of water; improved water management for rice cropping systems; management of salt in rivers and water bodies; more efficient water use by plantation trees and crops.
- **Groundwater resources and management:** better methodologies for improved groundwater management; improved education and training in groundwater science; management of groundwater salinity and on-farm salt disposal basins.
- **Land resources and inventory and evaluation:** improved methods for understanding land resources distribution (remote sensing, radar, digital elevation models, etc.); better analytical techniques to facilitate extrapolation using transfer functions, models and land evaluation systems; better land resource data management using geographical information systems and database technologies.
- **Land degradation processes, management and restoration:** greater knowledge of physical, chemical, biological, ecological and water balance processes of land degradation; models of land degradation processes and prediction of its impact.
- **Land and water contamination:** advanced technologies for measuring contaminants; new bioassays; better knowledge of the effects of agrochemicals; effects of land use changes on stream salinity in the Murray-Darling Basin; better education and training courses, and specialist consulting.
- **Remediation:** improved techniques for soil and groundwater remediation; quantitative understanding of multiphase behaviour of organics in soil and groundwater; more effective in situ monitoring; better knowledge of off-site impacts and natural remediation of organics in waters; trace analysis of organochlorines and toxic organics; acceptable remediation endpoints for regulatory agencies; new phytoremediation techniques for soils.
- **Waste utilisation:** identification of sustainable application rates for wastes; new approaches to de-watering and sludge characterisation.
- **Integrated resource use and society:** better approaches to conflict resolution in land and water use; methods for rational land use; improved frameworks for regional planning; better ability to integrate landscape issues; sounder pathways to meet future environmental challenges; modelling for land use change.

Customers, technology transfer and commercialisation

Research carried out for the sector has a high component of 'public good', with the Australian community envisaged as the main clients and fund providers. Customers include: urban and rural land managers; catchment, Landcare and community groups; industry

groups; research and development corporations; tertiary education institutions; local, regional, State and Federal Government and non-government agencies; and international government agencies and organisations.

Technology transfer and commercialisation are integral parts of most externally funded research. Technology transfer, in addition to publication of journal papers and reports, will include press articles and brochures describing research using, where necessary, non-technical language; also oral presentations at appropriate conferences, seminars, workshops and community gatherings. Technology will also be transferred using demonstration projects. There will be a significant involvement of non-CSIRO collaborators in this technology transfer. Training will also be undertaken, through lecturing, supervision and provision of specialist training courses.

Although commercialisation is a divisional responsibility, cross-divisional approaches will be developed and fostered to strengthen CSIRO's effectiveness in this area.

Marketing and communication

A sector marketing plan will be developed to ensure full customer awareness of CSIRO's R&D capabilities for the sector. Marketing will be based on the sector research and problem solving capability; it will involve the CSIRO Environmental Projects Office and will aim to attract strategic research funding.

Divisional communicators will play a key role in the sector. Their activities will be closely integrated into projects, to ensure rapid and effective dissemination of scientific advances. CSIRO will increase its efforts to make a constructive input to policy development for the sector, which is seen as an appropriate sector responsibility.

The sector divisions, by agreements among themselves, will provide the resources for marketing and communication.

Development of CSIRO's R&D capacity

The balance between basic, strategic and tactical work will vary across the components, but there needs to be an overall shift towards basic and strategic research. The majority of CSIRO's activity for this sector should be strategic.

To capitalise on opportunities, CSIRO will need to maintain disciplinary excellence in core areas of catchment hydrology, geochemistry, hydrogeology, soil chemistry, mineralogy and biology, to replace recent losses of senior scientists. The sector will need new skills in software engineering and risk analysis, and increased access to skills in modelling, resource economics and sociology. Staff development will need to be a high priority to retain competitiveness.

Specifically, CSIRO needs to develop its research capacity, through appointment, re-assignment or collaboration, in the following areas:

- **Analysis and monitoring:** analytical chemistry; *in situ* monitoring; GIS, remote sensing; image analysis; quantitative land evaluation; soil, water and crop data for precision farming; sediment-water fluxes; bioassays; biodiversity; ecosystem components; indicators.
- **Process understanding:** desertification; land degradation (salinity, acidity, sodicity, etc.); land management effects; phytoremediation and bioremediation; sludge dewatering; soil, sediment and wetland biogeochemistry; sedimentation; leaching and contaminant transport; water use by trees.
- **Modelling:** sediment transport; in-sediment processes; sludge characteristics; groundwater behaviour; coupling of physical and biogeochemical models; climate variability effects; resource economics; integration of models with GIS.
- **Information processing, transfer and management strategies:** GIS; spatial and temporal databases; risk analysis, decision support, graphical user interfaces; integrated waste management; social science.

Performance and evaluation measures

Performance reporting at sector level will largely depend on the performance reporting of individual divisions. Specific indicators of performance relating to the sector are:

- **Sector research activities:** performance will be indicated by the establishment of successful cross-divisional teams, large case studies and external collaboration, as well as by monitoring outputs, changes in appropriation, external and total expenditure on research (monitored annually and reported triennially) (PI 1).
- **External earnings:** will be reported annually against targets, based on divisional data (PI 2).
- **Adoption and impact:** will be monitored through successful uptake of research and technology by customers, inclusion of research findings in regulations and national policy, service on expert

committees, sales of software, instrumentation and other products (PI 3).

- **Customer satisfaction:** will be judged by repeat business and level of external support; a survey will be conducted late in the triennium following marketing and commercialisation activity (PI 4).
- **Publications, reports and patents:** numbers and kind will be reported annually (PI 5).
- **Training:** training through postgraduate students and vacation student programs will be reported annually (PI 6).

Sector Coordinator

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Divisional and other participation

CSIRO Office of Space Science and Applications, Coal and Energy Technology, Entomology, Forestry and Forest Products, Land and Water, Mathematical and Information Sciences, Tropical Agriculture, Wildlife and Ecology. CRCs: Catchment Hydrology, Soil and Land Management, Sustainable Development of Sugar Production, Waste Management and Pollution Control, Tropical Savannas, and Freshwater Ecology. Centre for Groundwater Studies.

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	20.2	20.7	21.2
External funding	11.6	11.7	12.0
TOTAL	**31.8**	**32.4**	**33.2**
External/total ratio	36%	36%	36%

The changes that have been made in the past two decades to the international legal regime applying to the marine environment are the most profound in human history.

The U.N Convention on the Law of the Sea came into effect in November 1994. It imposes obligations and confers rights on maritime nations which offer opportunities which previously did not exist. The most significant of these is the responsibility of coastal nations for their 200 nautical mile Exclusive Economic Zones (EEZ).

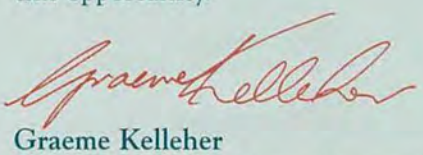
Not only are such nations obligated to protect their EEZs from the effects of human activity, including those emanating from land, but they have the right to exploit the resources of the area and to regulate, within limits, the access of other countries to those resources. The other side of this coin is that, if a country is unable to use those resources, it is obligated to make them available to other nations.

Australia has one of the world's largest EEZs. We face the challenge of managing this immense area in a responsible way—which may be summarised as achieving ecologically sustainable development. The foundation for this task must be our scientific knowledge and understanding of the marine environment and of the processes which sustain it.

CSIRO is uniquely equipped to provide this knowledge. No other institution in the world has direct access to such a wealth of scientific expertise, from virtually all scientific disciplines, relevant to this task. The challenge is to direct effort into the areas which will produce the greatest benefits to the people of Australia—both of the present generation and of future generations.

Experience worldwide has been that sectoral management of the sea fails, largely because the costs generated by one person or industry are imposed on others. Integrated Coastal Management, which addresses complete ecosystems, is the approach which offers an escape from the "tragedy of the commons". Within such an approach, the overall effects of human activity can be assessed scientifically and correspondingly managed. The interests of all sectors can be taken into account and provided for systematically.

CSIRO's Marine Sector now has the opportunity to harness its strengths, in cooperation with the rest of the Organisation and with others, to provide the scientific foundation for our major marine industries—tourism, fishing, oil and gas recovery and shipping—to produce material and spiritual benefit to Australians in ways which preserve and enhance the marine environment. The Sector Plan is an important step in taking this opportunity.



Graeme Kelleher
Chair, Marine Sector Advisory Committee

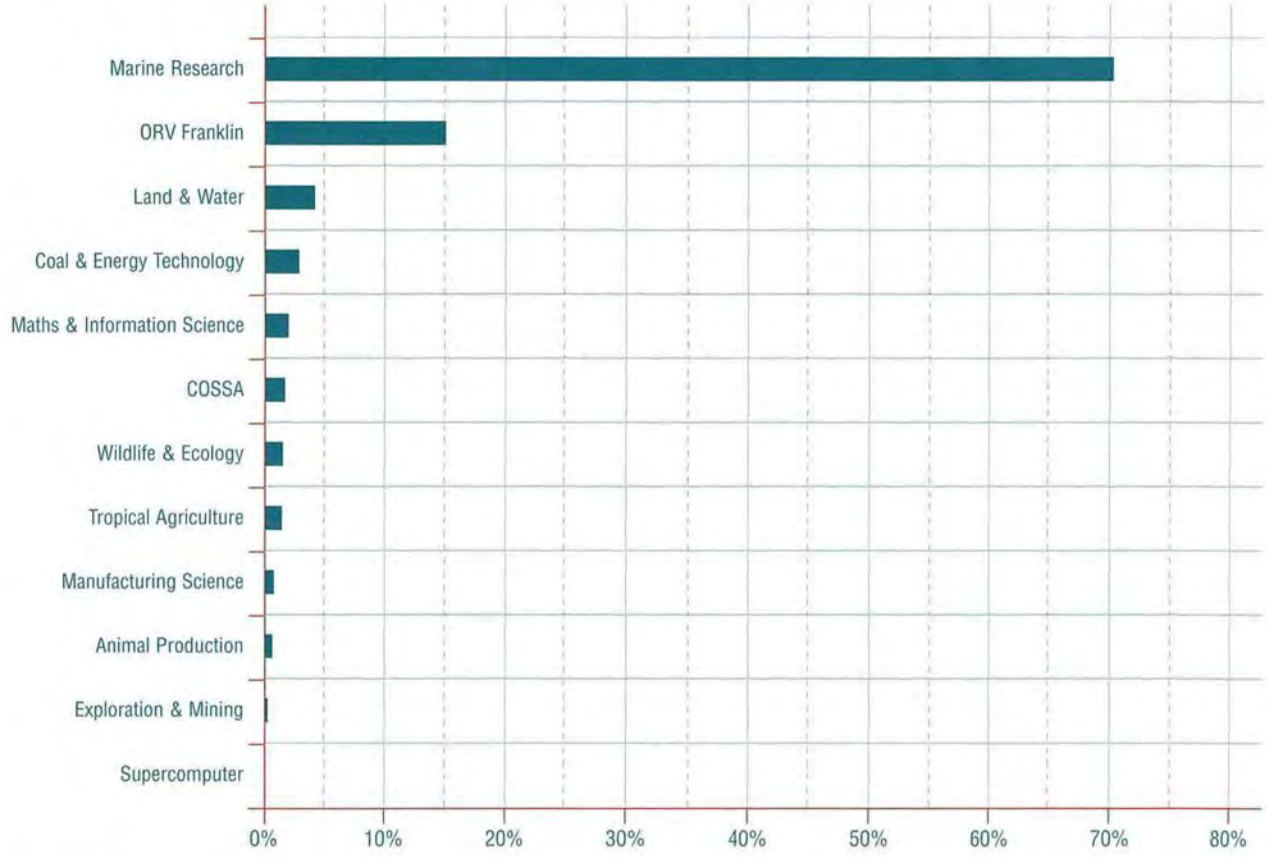
Marine Sector Advisory Committee:

Graeme Kelleher (Chair), IUCN Commission on National Parks & Protected Areas; *Ron Eagle*, NSW Public Works; *Helene Marsh*, James Cook University; *Richard Stevens*, Australian Fisheries Management Authority; *Peter Bridgewater*, Australian Nature Conservation Agency; *Ted Loveday*, Qld Commercial Fisherman's Organisation; *Russell Reichelt*, Australian Institute of Marine Science; *Mary Harwood*, Dept of Primary Industries & Energy

Marine

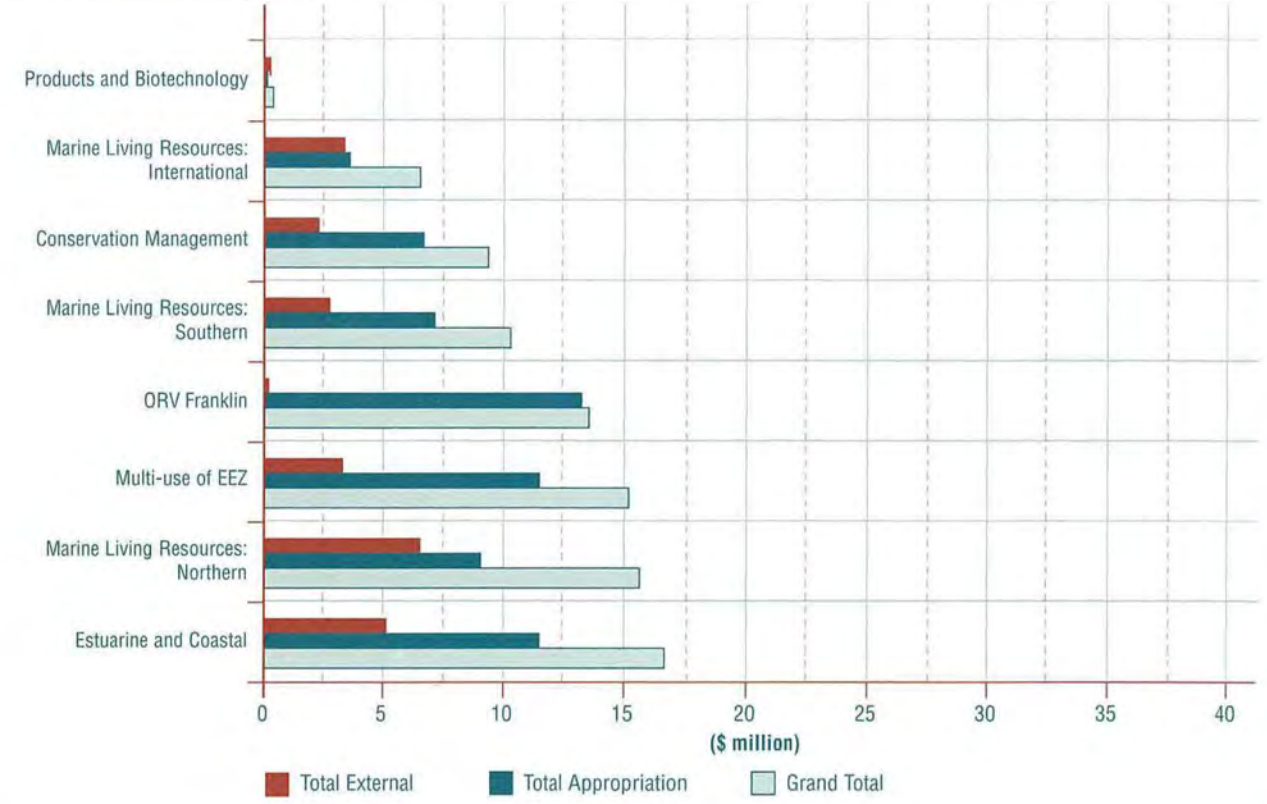
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $88.64 million)



Triennial Investment by Component

(Total Sector Investment $88.64million)



Mission

To deliver integrated and innovative science and technology in the national interest to guide exploration, exploitation and sustainable management of Australia's Exclusive Economic Zone (EEZ).

Overview

The sustainable development of its ocean is vital to Australia's economy and quality of life. The marine environment is used for a multiplicity of purposes, the diverse nature of which amplifies the need for a strong national research base linked to both the policy and regulation needs of government and the application needs of marine industries.

CSIRO's role for the sector is to provide:

- a national charter for marine research
- a leading custodian of Australian marine information
- support for government and industry to make sound decisions
- identification of emerging marine issues for Australia
- the maintenance of Australia's international reputation through quality science and collaboration
- the operation of the *RV Franklin* as a national facility, and *CSIRO Southern Surveyor*, and maximising return from these research ships
- the development of Australia's skills base through ongoing links between CSIRO divisions and universities.

The major issue to be addressed is the development and application of knowledge to enable the multiple use and development of marine resources at the same time as ensuring their ecological sustainability. Enhancing the understanding of, and discriminating between, natural and human impacts on the environment is essential to furthering sustainable management.

Key focus areas were originally identified in the Sector Outlook and Priorities Statement. After further analysis of CSIRO capability, feasibility and mandate, the research focuses are:

- multi-use management of Australia's EEZ
- marine living resources around Australia (northern, southern and internationally shared)
- marine conservation management
- marine products and biotechnology
- estuarine and coastal waters

The potential return to Australia from research in these areas is considerable. Marine industries are growing at a rapid rate of 8% pa in real terms—from $16 billion a year in 1987 to $30 billion a year in 1994 (including $6 billion in exports). It is predicted that by 2020 this will rise to $50–$80 billion. It is difficult to estimate the economic value of a healthy environment, although its intrinsic value is being increasingly recognised by the community. The maintenance of a healthy marine environment is critical to sustainable utilisation of marine resources and the realisation of the economic and social potential of Australia's oceans. Further details of the potential growth of major industries and the opportunities, needs and issues for industry, government and the community are contained in the Marine Sector Outlook publication.

The overall strategies or approaches to achieve the sector's mission are:

- to substantially increase fundamental knowledge and baseline data
- research and technological innovation—advances in computing, field techniques, remote sensing, rapid biodiversity assessment and ecosystem modelling
- a holistic approach to marine science—collaborating within CSIRO and with other organisations to assemble research teams to provide a whole ecosystem approach (including social sciences and management analysis when required)
- closer collaboration with the Australian Institute of Marine Science and a number of CRCs—Antarctic and Southern Ocean, Reef Research and Aquaculture
- strengthening of links with the CSIRO Environment Sectors (e.g. Land and Water), the Meat, Dairy and Aquaculture Sector, and the Petroleum Sector
- international cooperation to achieve world's best practice, and provision of research expertise to overseas countries where there is a clear benefit to Australia
- integration of scientific knowledge into policy development and management strategies, including the National Oceans Policy and the Marine Science and Technology Plan
- provision of advice to government, industry and the community on issues relevant to the development of marine living resources
- maximising return from Australia's national marine research fleet
- to seek external earnings to progress: environmental assessment of Australia's coastal zones and marine resource and tourism development; fisheries and multiple-use management strategies; real-time data for marine operations e.g. shipping, search and rescue, defence; marine products; export of R & D, especially environmental expertise, to Asia-Pacific

- support the government's objectives under the Coasts and Clean Seas Initiative, focusing on coastal pollution, environmental protection and marine biodiversity by targeting new funding sources, e.g. the Natural Heritage Trust of Australia.

The research directions in the plan have been developed in consultation with the Marine Sector Advisory Committee and through links to industry and government already well established by the sector's participating divisions. Important links exist to the Fisheries Research and Development Corporation; federal, State and international fishery and environmental management and conservation agencies (e.g. DEST, ANCA, GBRMPA, DPIE, AFMA, AQIS, TSRA); State port authorities; Bureau of Meteorology; industries including fishing, shipping, biotechnology, water services, mining and tourism; research bodies including AIMS and universities.

In developing the plan, new links have been established with CSIRO divisions not previously participating in the Marine Sector, including Exploration and Mining, Wildlife and Ecology.

Major objectives and key potential outcomes

Multi-use management of Australia's EEZ

- a framework for EEZ management strategies at regional and national scales
- ocean models for currents, temperature and physical characteristics
- ecosystem models that link food chain to primary production with fisheries dynamics and assessment
- regional studies that integrate physical, chemical and biological process studies—in the north-west shelf, tropics or eastern EEZ areas.

Potential outcomes

- development and evaluation of management strategies that will enable the sustainable multiple use of the EEZ
- improved knowledge of the resources, systems and processes in the EEZ.

Marine living resources around Australia

- **Northern Australia:** substantially increase the knowledge of the distribution, abundance, population dynamics and productivity of tropical marine living resources and their critical habitats focusing on the northern prawn, the Torres Strait tropical rock lobster, Torres Strait traditional fisheries, and key South-East Asian fisheries; improve understanding of the impacts of industry on the marine environment; substantially improve CSIRO's capabilities to map, monitor and measure the dynamics of ecosystems; develop integrated geographical information systems and decision support systems to enhance spatially-based multiple-use management.
- **Southern Australia:** estimate the stock structure and level of harvest that orange roughy, blue grenadier and Patagonia toothfish resources can sustain; determine management strategies to enable recovery of over-exploited resources, especially school shark and gemfish; identify key ecosystem processes that sustain Southern Australian fisheries, including those processes that might be at most risk from increasing effort; develop strategies for the protection and maintenance of biodiversity, especially on the continental shelf, deepwater volcanoes and Macquarie Island.
- **Internationally shared:** evaluate management strategy and assess stock for Australian input to the international management of southern bluefin tuna and other highly migratory large pelagic fish stocks; understand the biological, ecological and population dynamics of large pelagic fish and their role in the marine ecosystem.

Potential outcomes

- increased fundamental knowledge of the northern and southern Australian region to achieve new and better approaches to managing marine living resources at the ecosystem level; achieving ecologically sustainable development and sustainable Australian industries
- quantitative ecological modelling and risk assessment methods to guide ecologically sustainable fisheries development.
- a better understanding of the environmental impacts of industries (agriculture, tourism, fishing, mining and oil and gas) and development of options to ensure ecological sustainable development
- improved prospects for sustainable utilisation of Australia's internationally shared living resources (shared variously with Japan, New Zealand, Indonesia, Taiwan, Korea, China, USA, South Africa, PNG and Pacific Island states)
- sustainable Australian industries utilising internationally shared resources, including the southern bluefin tuna, yellowfin bigeye tuna, swordfish, orange roughy and red snapper fisheries and the black marlin game-fishing industry
- fulfilment of Australia's international commitments under various resource management commissions and

implementation of the UN Agreement on Highly Migratory Species and Shared Stocks.

Marine conservation management

- **Document marine biodiversity** for specific regions and taxa as a by-product of threat assessment and marine production studies.
- **Perform risk assessment** for major threatening processes and develop management strategies to deal with them.
- **Develop tools and strategies** for managing marine biodiversity, such as conservation management plans, rapid ecological assessment protocols, marine protected areas (MPAs). Perform cost benefit analysis of MPAs and develop criteria for need, size and location to ensure optimum sustainable ecological and economic development.
- **Explore options** and investigate innovative ways to monitor reef health using remote sensing.

Potential outcome

- improved evaluation and management of marine biodiversity.

Marine products and biotechnology

- Provide the research required to assist industry in the extraction and development of marine oils and related products from fisheries' by-catches.

Potential outcomes

- marine oils and value-added products for fisheries by-catches
- potential developments with polyunsaturated fatty-acid-producing Antarctic marine bacteria may assist the aquaculture industry.

Estuarine and coastal waters

- An integrated ecosystem approach to the understanding of the sources, fate and distribution of pollutants and their impact on coastal ecosystem function and amenity

Potential outcomes

- improved health of coastal waters and ecosystems
- measurement and modelling technologies and management tools for industry and environmental managers.

Summary of potential benefits across the five focus areas:

- improved information base
- scientific base for the sustainable, multiple-use management of the marine environment
- identification of new marine resources and/or industries
- determination of acceptable resource sustainability limits and indicators
- environmental conservation and protection
- significant contribution to determining best practice in all research focus areas.

Customers, technology transfer and commercialisation, and marketing and communication

The customer base comprises Federal and State governments and agencies, including conservation, tourism, defence, shipping and fishing; the resources sector, including oil, gas and other offshore operators; water authorities, including coastal management, marine park authorities and operators of marine outfalls; commercial operators and suppliers of products to the fishing, pharmaceutical, health and industry sectors; environmental and marine consultants. Customers receive both knowledge and hard technology.

Transfer of knowledge occurs in the public domain, through publications, workshops, seminars, and distribution of geographic information systems. The sector also engages in consultancies and contract research agreements, which deliver data and analysis for activities such as environmental impact statements, geographic information systems and ballast water management programs etc.

The transfer of technology-based devices occurs through licensing, including trade secrets, patents, confidential information and copyright. Technologies are developed and transferred either in collaboration with industry partners or by the sector addressing strategic research areas and licensing results for particular applications.

The Sector Advisory Committee assists the sector coordinator and chiefs to determine strategies to market CSIRO's capabilities for the sector. CSIRO has recently collaborated with government departments to develop a National Marine Awareness Program, which will provide a valuable mechanism for market initiatives. CSIRO divisions participating in the Marine Sector will collaborate to:

- raise the political, media, industry and corporate awareness of the role of marine science in the sustainable development of Australia's EEZ (through the National Marine Awareness Program)
- confirm CSIRO as Australia's leading marine science organisation

- build relationships between CSIRO scientists and clients for a better understanding of client needs and to ensure that CSIRO marine research is relevant to the nation.

Development of CSIRO's R&D capacity

CSIRO needs to:

- integrate existing disciplinary skills in physical, chemical and biological oceanography and modelling
- integrate bio-physical and spatial modelling capabilities
- develop ecosystem level modelling skills linked to management strategy evaluation
- develop and apply ocean observation systems including physical, chemical, biological and geophysical data. Three-dimensional data analysis schemes for the EEZ, using satellite and ship data
- develop the scientific framework for multi-use management
- develop innovative methods and models for population assessments of marine living resources. Enhance statistical techniques for stock assessment for sustainable management
- develop new technologies for studying the biology and ecology of pelagic populations (e.g. computerised and satellite-linked tags; remote sensing; light detection and ranging (LIDAR); otolith micro-chemistry; and micro-satellite genetic techniques)
- integrate geographical information systems and decision support systems incorporating statistical estimates of uncertainty and spatial modelling
- develop new manoeuvrable tow-fish, to enable controlled positioning of remote-towed video and sonar, to provide high-speed bio-physical assessments of the large areas of the sea bed
- perform environmental risk analyses and develop appropriate management strategies, molecular genetic technologies, by-catch reduction devices and environmentally friendly fishing gear, robust rapid assessment techniques for habitat-based management of biodiversity
- perform spatial modelling of marine climate impacts
- develop ballast water management techniques, protocols and technologies to reduce the impacts of marine pests
- develop technologies and models for assessing marine conservation values and threats to them
- develop marine inventory procedures
- develop coastal management measurement technologies, better understanding of processes, modelling techniques, statistical analysis and information processing
- develop a 3D hydrodynamic model for coastal marine system management.

Performance and evaluation measures

- development of new multi-disciplinary teams across the divisions in the sector
- resources shifted to key research focus areas
- successful delivery of outputs from major externally-funded studies and contracts
- adoption by clients of practices, instruments and processes
- the number of scientific publications in international peer-reviewed scientific journals
- the number of postgraduate students supervised and/or sponsored in key research focus areas
- continued external earnings

Sector Coordinator

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Divisional and other participation

Marine Research, Mathematical and Information Sciences, Coal and Energy Technology, Land and Water, Wildlife and Ecology, CSIRO Office of Space Science and Applications, Exploration and Mining, Tropical Agriculture, Manufacturing Science and Technology, Animal Production, ORV Franklin. CRCs: Antarctic and Southern Ocean, Reef Research, Aquaculture. Australian Institute of Marine Science.

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	20.8	22.1	22.0
External funding	7.6	7.9	8.2
TOTAL	**28.4**	**30.0**	**30.2**
External/total ratio	27%	26%	27%
Excluding *RV Franklin*, external/total ratios are:	32%	32%	33%

Information Technology and Telecommunications

The IT&T SAC was established with a membership aimed at achieving a balance of information technology and telecommunications industry experience, technical and marketing skills, and private and public sector backgrounds. The Committee met in formal session on two occasions during the second half of 1996, and in addition the Sector Coordinator (Dr Dennis Cooper) had out of session discussions with individual members of the Committee to progress issues on the Plan development.

The Committee has appreciated the efforts made by CSIRO management to provide meaningful information to it, and also the manner in which the views of the Committee have been incorporated into the Sector Plan.

The Sector Advisory Committee is therefore able to strongly endorse the IT&T Sector Plan as now developed and recommends that appropriate resources be allocated and maintained for its implementation.

The IT&T Sector should be accorded a high priority in resource allocation not only because it can produce direct outputs of value to the Australian economy but also because the underlying competencies created are necessary to support almost every other Sector in the CSIRO program. These are now essential tools in all areas of scientific and engineering endeavour, and while skills will be distributed through all divisions, the core competencies should be maintained in Telecommunications and Industrial Physics (telecommunications) and Mathematical and Information Sciences (information technology).

The Component Research Plans (CRP) for this sector fall into three distinct categories:

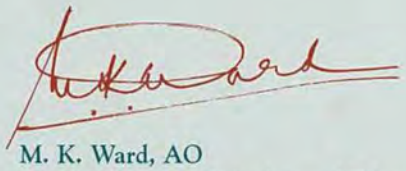
(a) An integrated set of telecommunications plans based on radio communications. In this area CSIRO has an established critical mass of research capability which should be maintained and preferably enhanced. In the particular area of millimetre wave technology and Gallium Arsenide semiconductor fabrication, the CSIRO skill set is unique in Australia and this offers a real competitive advantage across the integrated set.

(b) An integrated set of newly emerging IT CRP's comprising Interactive Media Systems, Electronic Commerce, and Spatial Information Systems. These again have strong mutual dependencies when viewed from the perspective of the underlying competencies, methodologies, and techniques. This area is significantly application driven and CSIRO potential for commercial benefit is high. The SAC has expressed the view that attention continue to be paid to extracting the generic and longer term research component of this work.

(c) A pair of newer and more speculative project areas which have high potential benefits but are subject to greater uncertainty as to the achievability of this potential. The first of these is the Software Engineering Initiative and the second is Advanced Telecommunications Services. In both of these cases, the Advisory Committee believes that support should be given, but that closer monitoring should be undertaken to progressively assess the achieved outcomes.

On a general level the Committee has expressed concern that pressing for a 40% target of external contract funding may unfavourably distort research effort, and the revised target of 35% is endorsed. It also believes that enhanced alliances with multinational partners must be sought to best capture R&D benefits.

The development plans endorsed for the IT&T Sector recognise the practical realities of building on the existing CSIRO strengths in an incremental way. No revolutionary changes are proposed but a process of ongoing monitoring should be clearly established to ensure that the evolution continues.



M. K. Ward, AO
Chair, Information Technology and Telecommunications Sector Advisory Committee

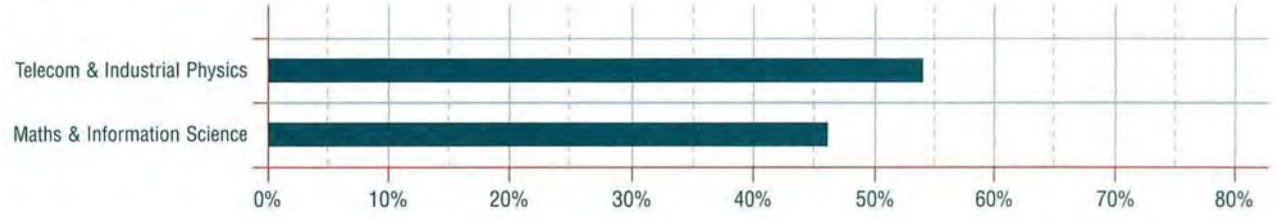
Information Technology & Telecommunications Sector Advisory Committee:

Mel Ward (Chair), Consultant; *Lyndsey Cattermole*, Aspect Computing Pty Ltd; *David Laidlaw*, ISSC Australia; *Val Mickan*, Silicon Graphics Pty Ltd; *Ockert van Zyl*, Siemens Ltd; *Roger Buckeridge*, Allen & Buckeridge Pty Ltd; *Rob Cook*, CITR Pty Ltd; *Andy Macdonald*, Office of Govt Information Technology; *Peter Rule*, Ericsson Australia Pty Ltd

Information Technology and Telecommunications

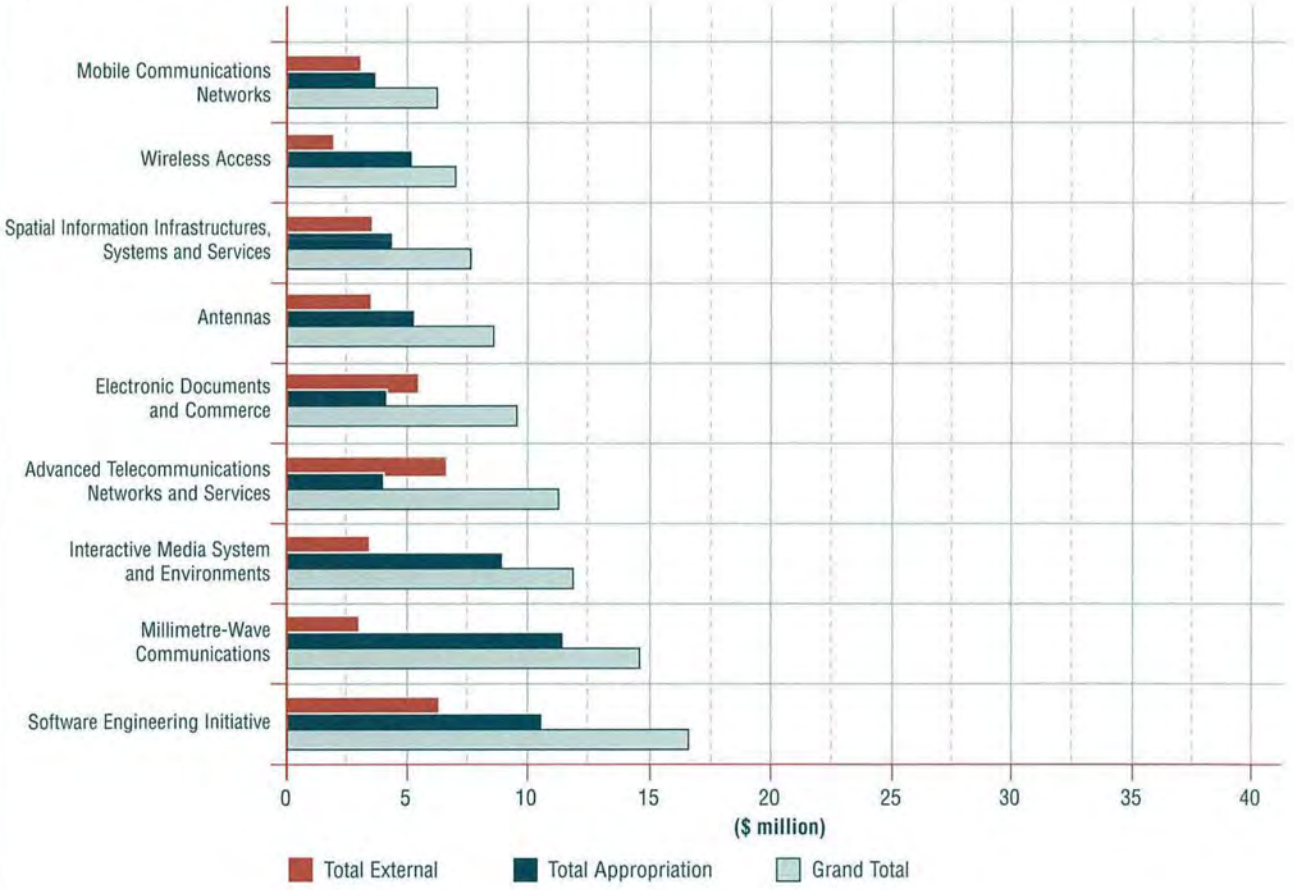
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $86.70 million)



Triennial Investment by Component

(Total Sector Investment $86.70 million)



Information Technology and Telecommunications

Mission

To become a globally-competitive source of innovation for Australian industry in the information technology and telecommunications (IT&T) sector, through the development of advanced technologies, tools and skills supporting the business needs today and for the future. CSIRO will also contribute by maintaining sizeable research groups providing a knowledgeable resource for industry.

Overview

IT&T solutions play a major role in competitiveness in every part of the value chain and every part of the economy. They are an essential ingredient if Australian companies are to offer globally competitive products and services. IT&T research enables Australian enterprises to access specialists capable of developing innovative solutions to leading-edge competitive problems. Without this access, Australian enterprises would only be able to utilise imported technology and obtain no advantage over their competitors.

CSIRO can establish research effort of critical mass which the small indigenous companies (small by world standards) cannot afford. By focusing on specific competitive issues, CSIRO is able to provide early market opportunities to these Australian-based companies. The benefit from becoming a market-leader in a particular field endures long after the research has been completed.

CSIRO's role is to provide a research focus, complementing and bridging business enterprise R&D (one to two year time frame) and university research (generally beyond five years). CSIRO will develop and maintain a sustainable structure for its research in this sector by:

- developing and maintaining world-class expertise of critical mass across a range of core technologies relevant to Australian firms, both now and for the future
- assembling teams from across CSIRO's technology base to address specific problems or opportunities identified by its customers
- developing strong links with potential recipients of research results through collaboration with other sectors, particularly in the Services Sector and
- involving users of CSIRO's research results actively from an early stage.

The IT&T Sector is one of the fastest growing in the economy, with a sustained growth rate approaching 12% over the last five years. It now accounts for some $50 billion in sales, with exports close to $4 billion, and is growing at 15% a year. R&D expenditure exceeds $1 billion with a growth rate matching the revenue.

The industry today is driven by:

1. the explosion in network (especially Internet/Intranet) services and access, and their adoption by business
2. deregulation in the telecommunications industry globally
3. the emergence of a common infrastructure for computing, media and telecommunications
4. networks convergence of computers, communications and media.

These issues have introduced intense competition to the industry and placed a premium on productivity and differentiation of service, areas where innovation and R&D are vitally important. In addition IT&T is a major input to every sector of the economy, making it doubly important that efficient up-to-date technologies and skills are available to maintain competitiveness across the entire economy. It is important that Australia develop indigenous skills to create world-class competitive products, systems and services based on its strong domestic user and industry base. Perhaps more than any other sector IT&T faces global competition both domestically and internationally.

The Sector Outlook document discussed the key areas of interest, which were initially chosen after industry surveys by interview:

- a dramatic increase in the use of the network services by both business and consumers
- customer access and differentiation of service for telecommunications carriers
- the need to improve productivity and quality in software development.

CSIRO's research strategy of addressing these areas was strongly endorsed by the Sector Advisory Committee.

The Component Research Plans in this sector fall into three distinct groups:

- The first builds on CSIRO's long-standing strengths in radio communications covering mobile systems, wireless access, mm-wave expertise and antennas. These areas are all strongly interdependent and often use common technologies to solve different systems problems.
- The second anticipates further development of CSIRO's significant capabilities in newly emerging IT

technologies including Internet-based electronic commerce, interactive media systems and spatial information systems.

- Finally, two new areas: software engineering, aimed at improving software quality and productivity; and the network services area, which is developing expertise to support networked applications and customer access.

When commenting on the Component Research Plans, the Sector Advisory Committee concluded that the greatest potential lay in the wireless and mobile communication areas, but that capturing benefits would rely heavily on establishing strong links with multinationals and their alliance partners in Australia. In the IT area the committee emphasised the need for an applications orientation. The committee believed that there was good earnings potential, although there might be difficulties in relying on a consultancy-based approach. There was a need to form alliances with the local multinationals to remain competitive. There was also a need to increase the research capacity, with an appropriate focus on electronic commerce.

The committee agreed on the importance of software engineering to all those industries reliant on software development (including many service industries and telecommunications) but expressed concerns about whether the existing culture in Australian software development teams would allow the benefits to be captured. This concern has been addressed in the research plan and will be monitored in conjunction with the advisory committee.

In network services, the research will focus closely on areas where Australia can benefit: applications-related quality of service issues, an increasing collaboration with interactive media, and ATM network issues related to wireless access.

Major objectives and outcomes

The overall objective for the sector is to provide support for Australian-based enterprises by developing key technologies and skills to support their business needs. This will require CSIRO to be closely tuned to industry trends, local company strengths, their domestic and export opportunities and their longer term needs.

The broad areas of need identified, and endorsed by the advisory committee, are:

- support in the network services products, both Internet and Intranet
- customer access technologies, particularly radio-based
- improved quality and productivity of software-based systems.

Important objectives arising from these aims are to

- develop technology for companies providing interactive media products and systems integration, demonstrate online services and establish a 'Useability Laboratory' to support multimedia developers
- develop technologies which can apply the rapidly developing Internet and electronic document-oriented infrastructures to create advanced business systems
- focus spatial information systems on systems-level issues for networked heterogeneous environments
- build strong systems capabilities in all aspects of mobile communications, through the development of demonstrations of systems and applications
- establish a realistic multi-node, multi-site research network to trial applications, verify network modelling and traffic management techniques, and demonstrate ATM services
- develop technologies for wireless access products, including microwave technologies for size and cost reduction, duplexing systems, high-speed modems and low cost packaging
- provide the telecommunications and defence industry with systems solutions incorporating fully-integrated mm-wave transceiver components and inexpensive plastic packaging
- develop techniques for the design and manufacture of antennas and passive microwave devices, and components for electronic and communication systems
- develop effective software engineering methods, tools and techniques and ensure the effective transfer of these to industry.

The expected outcomes include

- increased software quality and productivity of Australia's software development groups through transfer of improvements to the software development process and associated software engineering methods, tools and techniques
- demonstration and commercialisation of interactive, multi-media systems for accessing large distributed databases for media and information services
- methodologies and tools for document management of complex, linked, virtual and active documents and archiving for future access

- commercialised software tools for providers of tailored information supply from common enterprise or global data sources, through delivery channels such as CD-ROM, Internet, broadband services and kiosks
- effective tools, methodologies and strategies for advisory and help systems
- commercialised tools for the more effective use of Internet and Intranet systems for corporate applications
- demonstrate and commercialise services that generate earth observation data products from data archives at many sites
- demonstration and commercialisation of a millimetre-wave wideband customer access system, capable of large volume production at consumer cost levels, suitable for fast roll-out, second carriers and newly industrialised export markets, obviating the need for overhead cables
- demonstration of scalable mobile multi-media service technology with position determination, video-conferencing and portable office facilities
- demonstration of PCS base-station systems based on technology for smart antennas, power amplifiers and baseband processors with a mobility-enabled ATM switch for interconnection
- development of self-sufficiency in Australia in advanced millimetre-wave system design and manufacturing, to satisfy the communications and defence industries.

Customers, commercialisation and marketing

IT&T is a global business, but Australia is a long way from major markets and product development centres. However, there is a significant leading-edge sophisticated IT&T user base, strong educational and research infrastructure and a substantial industry base which is growing strongly.

CSIRO has strong, long-standing relationships with a variety of international research institutions, and is active in numerous international bodies and conferences. In some areas, such as the ATM Forum, CSIRO is an active participant and leader.

CSIRO has developed strong links to IT&T user industries, through CSIRO multi-divisional projects with IT application development and service provider companies, in sectors such as mining, manufacturing, petroleum, water resources, utilities and media.

Australian organisations have specific niches of expertise which enable them to participate in global markets and add value here. The key to accessing global markets is to work through multinational corporations. Many of them have shown interest in working with local small and medium-sized companies (SMEs).

CSIRO continues to seek marketing opportunities in Australian and international forums where Australian-based multinationals and export-oriented SMEs are active. Since 1994 CSIRO has maintained a high profile at the CeBIT exhibitions in Hanover, Germany.

CSIRO will continue to work with SMEs where there are opportunities to enable international markets that can be developed in partnership with Australian-based multinationals-for example Microwave Networks Australia and California Microwave.

CSIRO has developed a network of multinational partnerships through its significant involvement in several major Cooperative Research Centres' technologies (RDN, DSTC, ACSys). Multinational corporations provide important local and international commercialisation channels for indigenous research.

CSIRO R&D capacity

CSIRO has a program of science and engineering development targeted at the major opportunities in the sector where significant technical development is anticipated. These areas are:

- customer access and service differentiation for telecommunications
- network (especially Internet/Intranet) services and access
- improved quality and productivity in software development.

Although focused, this work includes basic research as well as the development of engineering skills. Among the main areas of research concentration are the following:

- the development of new technology for smarter antennas, high-speed modems and modulation systems for wireless and mobile access purposes
- millimetre-wave communications technology, including GaAs MMIC design and fabrication capabilities
- fundamental work on quality-of-service issues for applications on advanced telecommunications networks, including ATM and wireless systems
- the archiving and retrieval of documents, video and other media via the Internet and other networks

- human-computer interface, visualisation and content-based manipulation software development for interactive media
- technology for the manipulation and storage of large databases
- capabilities for development of virtual reality industry applications
- techniques for information representation, classification and retrieval, metadata, and the structure, link and interaction of electronic information components
- internet/Intranet technologies that meet the needs of electronic commerce, corporate knowledge—management and distributed applications
- the development of knowledge-based systems and software agents and fundamental advances in software engineering processes, methods and technologies.

CSIRO has contributed to, and benefited from, the creation of a critical mass of IT research skills through its participation in Cooperative Research Centres and its location on university sites—ANU and Macquarie University—where complementary research is conducted.

Performance and evaluation measures

The research described in the Component Research Plan will be monitored on a continual basis in consultation with the Sector Advisory Committee. Annual reviews will be undertaken to evaluate the achievements, reassess directions and industry interactions.

The critical performance indicators for the sector will be:

- the development of skills relevant to the local industry base
- the ability to meet the target external earnings
- links with multinational companies and local alliance partners (building on the continuing government policy of Partnership for Development programs) and
- take up of technology developments by customers together with measures of customer satisfaction.

The advisory committee stressed the need to establish strong alliances with Australian-based multinational companies and their indigenous alliance partners to ensure access to global markets.

Sector Coordinator

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Divisional and other participation

Telecommunications and Industrial Physics (92.4 EFT), Mathematical and Information Sciences (77.2 EFT).
Macquarie University (JRCASE, 5 EFT)

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	19.6	19.5	19.5
External funding	8.4	9.2	10.5
TOTAL	**28.0**	**28.7**	**30.0**
External/total ratio	30%	32%	35%

Built Environment

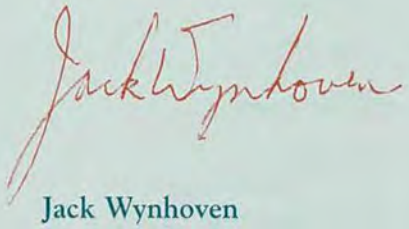
Sector Foreword

As Chairman of the Sector Advisory Committee and past Chairman of the Division of Building, Construction and Engineering Advisory Council, I am pleased to support the Sector Plan and the strategies it contains in response to your Strategic Research Directions. I would like to highlight the following:

- As you have identified, infrastructure and broad environmental links is an emerging opportunity. We believe the time to act is now and welcome the change of name from Infrastructure to the Built Environment Sector to signal a new direction and your support.
- The Built Environment Sector with its new focus merits a significant increase in its priority assessment. The diverse nature of this Sector and the cyclical nature of many parts of the industry has historically impeded a high direct contribution by industry to research and development. The new focus on the combined industries of utilities, transport and construction provides a large common market for a significant number of business enterprises. These businesses are already exploiting the new opportunities associated with government reforms, including important initiatives in build own, operate and transfer projects (BOOT), privatisation and the application of performance based regulations and codes. Industry and government funded research will play an important role in the transformation of this Sector which provides such a significant impact on the efficiency of our economy and our standard of living.
- As Chairman of this newly formed Committee I heartily endorse this Sector's new directions; in particular a strategy of rigorous review. This proposed process will allow our Committee the opportunity for a closer examination of scientific advances being attempted in this new Sector and the ability to provide timely guidance in its evolving strategy. Our foremost priority is a focus on ecologically sustainable development. We must provide our future generations with the highest possible quality of life through prudent and appropriate use of our existing resources. We are certain research is essential in achieving this objective and look forward to working together to build an exciting future.

I congratulate you on behalf of the Sector Advisory Committee and the industries we represent on your new direction for CSIRO.

Yours sincerely,



Jack Wynhoven
Chair, Built Environment Sector Advisory Committee

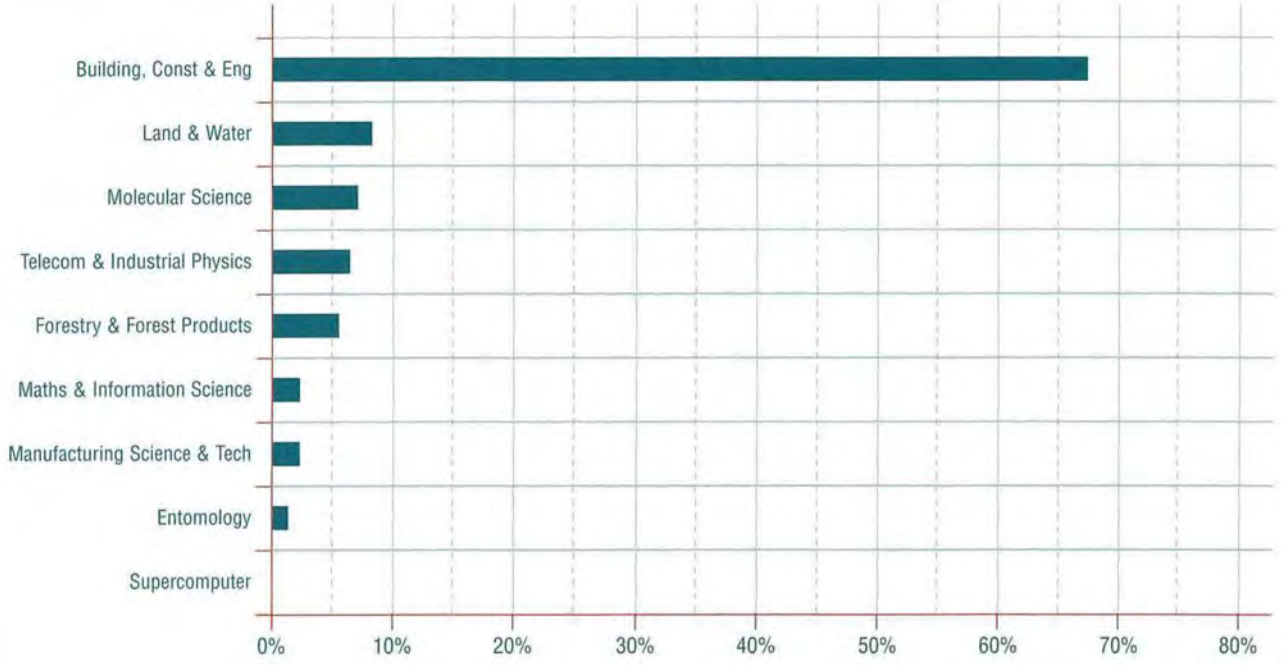
Built Environment Sector Advisory Committee:

Jack Wynhoven (Chair), Connell Wagner; *Alan Evans*, Dept of Industry, Science & Tourism; *John Morgan*, Melbourne Water; *Bill Service*, Saltcoats Consulting Pty Ltd; *Yvonne von Hartel*, Robert Peck von Hartel Trethowan; *Alan Castleman*, Western Metals Ltd; *Ian Johnston*, Government Property Office, WA; *Michael Sargent*, ACTEW Corporation Ltd; *David Thomson*, Roads and Traffic Authority (NSW); *Lionel Wonneberger*, Thomson Radar Australia Corporation

Built Environment

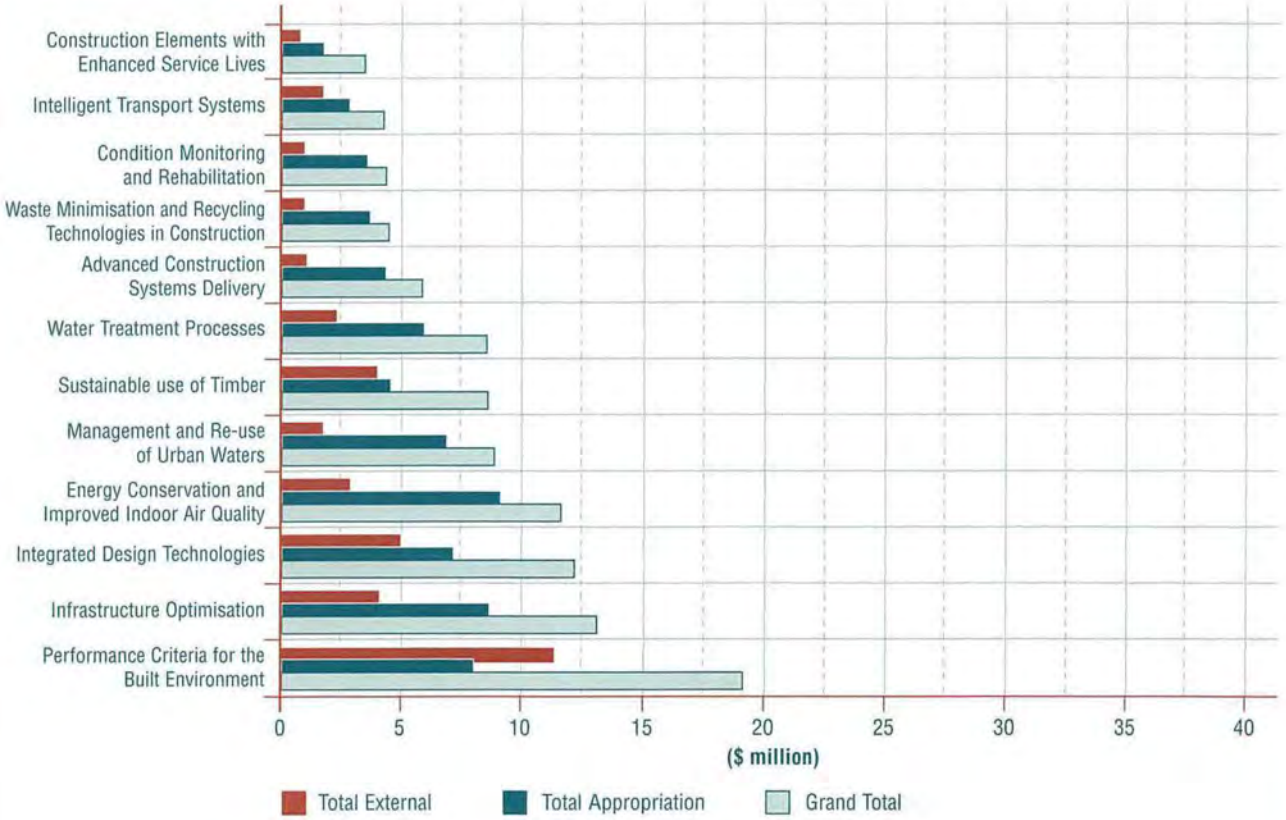
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $103.93 million)



Triennial Investment by Component

(Total Sector Investment $103.93 million)

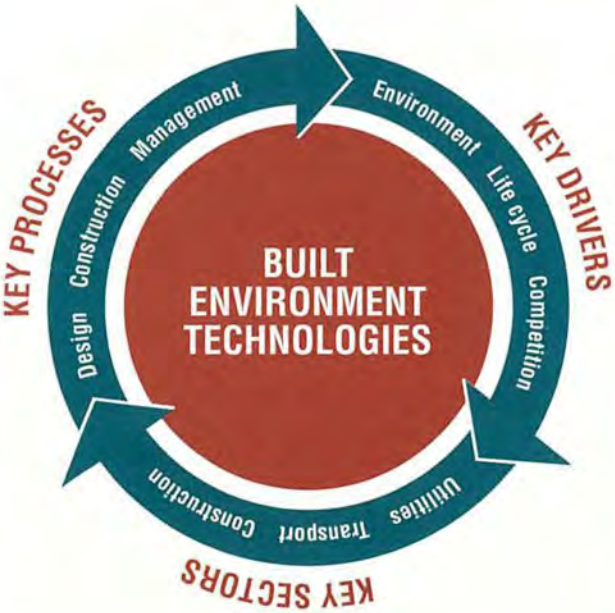


Mission

To improve the nation's economic competitiveness and quality of life by focusing world-leading research on the individual and combined components of the built environment.

Overview

Ecologically sustainable urban development is the nation's greatest challenge in the 21st century. In responding to this challenge CSIRO will develop and assist in the application of new **built environment technologies** (BETs) that will enhance the liveability, serviceability and competitiveness of cities in an increasingly global economy. This requires an integrated approach towards the design, construction and management of the nation's infrastructure, an approach that encompasses the key industry sectors of construction, transport and utilities.



This sector will bridge the often independent streams of engineering science and environmental research. A new interdisciplinary and inter-divisional approach which combines the diverse resources of CSIRO in the identification, selection and achievement of highest priority science projects is envisioned.

A new model of sector operation will provide the framework and processes to select, resource and monitor achievement of outcomes. It will entail a sector investment and review committee of eight in addition to the sector coordinator. Committee membership will include equal representation from the environmental and engineering based sectors.

These sectors are important collaborators in the research effort on the built environment. This committee will oversee ongoing rigorous assessment of research activities starting with a staged review of each of the Component Research Plans, involving working commissions with invited international research leaders and industry representation. The evolving strategy for each Component Research Plan will be provided to the Sector Advisory Committee for approval.

A conference on built environment technology for ecologically sustainable urban development in 1997 will provide the first demonstrable milestone in achieving CSIRO's new focus for this sector.

Infrastructure is the second largest sector in Australia's economy, comprising some 16% of Gross Domestic Product. The sector includes all activities involved in the planning, design, construction, maintenance, repair and disposal of buildings. It provides the nation's roads, rail, ports, air transport, water, gas and electricity. All the nation's trade relies on this sector's assets as a fixed cost which determines our international competitiveness. DITAC (1992) has stated that no other sector can produce the economic benefits of this sector. A reduction of 10% in the costs of infrastructure would be the same as a 6.5% growth in GDP—something of the order of $26 billion.

In addition, the emergence of Asian megacities and a booming Asian infrastructure market at least 100 times that of Australia has meant that Australian infrastructure companies expect to have at least 50% of their turnover off-shore by year 2000. This will lead to similar economic benefits flowing back to the nation. Australia's built environment technologies represent a major export opportunity globally.

Equally important is the impact that built environment technologies and the infrastructure that ensues has on our quality of life. They affect the efficiency with which we get to work, the standard of health, safety and public amenity in our buildings. They combine to create our built environment. Their level of technical performance combines to determine the quality of that built environment, in key areas such as traffic congestion, indoor and outdoor air quality, waste generation and disposal. All are key concerns of the population.

The size and ubiquitous nature of this sector offers challenges to participating industries. These industries are often fragmented, undercapitalised, and composed of many small firms without the scale of operations or vertical integration to support strategic research. Such

industries have historically depended upon government R&D as a means of lifting standards and efficiency. However, sweeping industry reforms such as privatisation, deregulation, outsourcing of R&D and performance-based standards are now providing new research opportunities. CSIRO,with its breadth of skills, is uniquely positioned to provide research that can have significant impact. The challenge is to identify the specific opportunities where, together with industry, CSIRO can achieve a significant impact.

The signs are encouraging. Recent trends in R&D expenditure by business enterprises in Australia (1993–95) indicates that key areas within the sector are investing significantly in R&D. For example, architectural, surveying and engineering services have grown from $96 million to $133 million over the past two years, while utilities R&D has increased from $57 million to $129 million over the same period. Construction and transport R&D outlays have remained relatively constant, around $12 million a year (Australian Bureau of Statistics figures, 1996).

Major objectives and key potential outcomes

Consultation with industry, construction, utilities and transport agencies has identified three key issues to be addressed by the sector:

1. Ecologically sustainable development

APPROPRIATION	INCREASE
EXTERNAL EARNINGS	INCREASE

The Australian built environment falls well short of the environmental objectives expressed by government and international agreements. Australia's energy consumption—a significant cost to business—has increased by 37%, while other countries have reduced by 30%. Some 60% of energy consumption occurs within this sector. In addition, threats to air and water quality in Australia are of national concern (e.g. biological degradation and wastewater impacts). Moreover, Australia produces more municipal waste per capita than any other industrialised nation.

2. Durability of materials and efficient systems performance

APPROPRIATION	DECREASE
EXTERNAL EARNINGS	INCREASE

Our $1200 billion investment in the built environment is ageing, with an ever increasing maintenance and rehabilitation cost, now consuming $30 billion a year. The performance and durability of building materials directly impacts on these costs. The built environment is a substantial portion (some 20%) of the cost of traded goods, and directly affects our quality of life and international competitiveness.

3. Improved firm, industry and national competitiveness

APPROPRIATION	STEADY
EXTERNAL EARNINGS	INCREASE

Industry production of large-scale one-off projects (estimated at $60 billion a year) involves constantly changing industry participants (120 000 firms) in an information intensive industry (there are often 100 000 individual documents on a $100 million project). This is inefficient. It calls for development and adoption of advanced technology products and processes associated with design, planning, construction, operation and maintenance of facilities and infrastructures to drive international competitiveness.

The outcomes and benefits of addressing these issues are significant. They include, for example:

- deeper knowledge of the complex and dynamic urban processes that drive the growth of modern cities and their infrastructure networks. These processes can be modelled, using simulation and optimisation, to produce more innovative forms of urban development and infrastructures
- the reduction in wastes, energy consumption and pollution
- the establishment of common information protocols and new decision support systems capable of reducing the cost of construction by 10%, enhancing operating efficiency, and leading to new export opportunities in the rapidly growing Asian marketplace
- innovative urban construction systems, including integration of information technologies and communications, as a network-based system for construction
- improved understanding of the performance of materials in built structures and their environmental impact can significantly reduce the lifetime cost of assets and their environmental impact
- new large-scale decision support systems will provide utilities with the necessary information to meet an increasing requirement for more efficient,

competitive and environmentally sensitive delivery of services. Efficiency can also be enhanced through technology, particularly in the cost-efficient use of new technology in the treatment and management of urban water and in power transmission

- improved transport service, greater efficiencies and safety can be achieved through adoption of advanced automation and information technologies. These technologies and concepts are applicable to all aspects of transport: planning and scheduling journeys, traffic monitoring and control, vehicle efficiency and environmental effects, tolling and enforcement, traveller information and traffic management systems.

Customers, technology transfer and commercialisation; marketing and communication

CSIRO has well-developed relationships with key industry Built Environment Sector customers in Australia and overseas. These customers range from international conglomerates like Boral (a major utility provider in Australia), to mid-size companies such as consulting engineers Connell Wagner, to a plethora of small architectural services. The industry has traditionally relied on CSIRO, through its appropriation and expertise, to be the independent expert in providing industry standards.

If CSIRO is to satisfy its customers in the coming triennium, it faces three challenges: to continue to provide applied research advice on a full cost recovery basis, to develop new industry support for strategic research and to ensure that adequate appropriation funding is directed toward key industry issues involving public good, such as ecologically sustainable development.

To recover more of its costs, CSIRO will have to increase its prices in particular markets, focusing on winners, forging long-term alliances with key customers and improving efficiency in the provision of services. This can be achieved through sector-coordinated marketing and customer service centres, offering an integrated presentation of CSIRO's breadth of skills, with a priority on achieving repeat business.

Two key thrusts are proposed for developing new industry support for strategic research. The first is a marketing effort aimed at the professional associations, where the under-capitalised industry participants can contribute their share of the support for strategic research. The second calls for the development of relationships with the new entities now being formed as the government privatises its traditional infrastructure delivery services.

The continued provision of appropriation funds for 'public good' research on the built environment will require CSIRO to work more closely with national research effort on the physical environment. Further links will be developed through the Built Environment Sector Investment and Review Committee and other sector and alliance meetings.

There will be coordinated marketing and communication activities from contributing divisions within the sector. These activities will include preparation of feature articles on leading-edge technology in the Division of Building, Construction and Engineering's Innovation magazine, which will now have a sectoral coverage. In addition, multimedia publication on Internet will be explored, as well as traditional avenues for publication of scientific reports. The challenge is to accelerate the transfer of new knowledge to a dispersed and fragmented industry sector.

Development of CSIRO's R&D capacity

Research emphasis will be placed within the areas of the three key issues as follows:

Ecologically sustainable development

- experimental and numerical models of ventilation and energy flows in buildings; methodologies for the evaluation of their impacts
- laser-based diagnostics for the study of high efficiency/low emission combustion systems, especially using pulse combustion for heating and cooling systems
- protocols for waste characterisation based on material chemistry and waste material processing techniques, as well as the reuse/recycling potential in construction
- mechanisms by which pollutants are emitted from materials; models of pollutant emissions from materials and their impact on indoor air quality
- water/wastewater process design, surface chemistry and engineering
- magnetic microparticle preparation and handling for water treatment, including interparticle forces
- systems analytical and engineering design skills for urban stormwater management
- mathematical models capable of simulating and optimising, in an integrated manner, key elements of

large urban systems, including landuse, transport and environment.

Durability of materials and efficient systems performance

- improved performance of building materials and models of design for durability
- smart materials, which can adapt or respond to their environment during construction and service life
- high temperature super-conducting cables
- models of uncertainty and variability in sawn wood production and end-use
- physico-chemical modelling of environment-building system interactions, to understand the rate of deterioration of material components.

Improved firm, industry and national competitiveness

- computational and experimental fluid dynamic models, to understand the pyrolysis of combustible building materials when exposed to radiative and convective heat fluxes; the behaviour of these and other building materials at high temperature in complex built structures
- integration of CAD and design performance analysis software (in thermal performance, acoustics, ventilation, fire, structures, etc.)
- computational models for faster and more accurate analysis of indeterminate systems (e.g. for structural analysis, air and climate control, fire hazard analysis)
- new mathematical models for facility location, using techniques such as spatial optimisation, simulation and visualisation
- system integration of civil engineering, geomatics and economics to generate a knowledge platform for understanding dynamics of urban and regional systems
- decision support systems that allow each construction project participant real time access to all the up-to-date information, and automated tracking of design changes
- knowledge-based systems for planning, design and construction of buildings including BCAider Design and Fire Expert
- development of CAD conferencing between remote construction sites and design offices, using broadband communications
- capture, fusion and real-time processing methods for identification of vehicles and optimisation of their movements and routes
- high fidelity distributed computer simulation modelling of mixed-mode traffic and public transport systems, to assess benefits, verify designs and assist with testing and developing 'day of operation' algorithms.

Performance and evaluation measures

1. Peer recognition e.g. invitation, keynote, publication
2. % external earnings ratio
3. % customer satisfaction
4. ROI (project benefit statement)
5. Adoption of CSIRO technology.

Sector coordinator

Mr Larry Little
CSIRO Building, Construction & Engineering
Tel. (03) 9252 6114, fax (03) 9252 6241
email: Larry.Little@mel.dbce.csiro.au

Divisional participation

Building, Construction and Engineering (67%), Land and Water (7.9%), Molecular Science (7%), Telecommunications and Industrial Physics (6.6%), Forestry and Forest Products (5.2%), Mathematical and Information Sciences (2.4%), Manufacturing Science and Technology (2.4%), Entomology (1%).

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	21.8	22.9	23.2
External funding	10.8	12.2	13.0
TOTAL	**32.6**	**35.1**	**36.2**
External/total ratio	33%	35%	36%

Measurement Standards

Sector Foreword

The CSIRO Measurement Standards Sector Plan addresses the following imperatives:

- the legislative requirement for CSIRO "to maintain, or cause to be maintained, the Australian physical standards of measurement" and "to promote, and participate in, the development of calibration with respect to them";
- the Government's requirement of CSIRO to provide expert advice on measurement system infrastructure to underpin its domestic and international trade objectives;
- the Government's response to the recommendations of the Independent Inquiry into Australia's Standards and Conformance Infrastructure, particularly the recommendations that the National Measurement Laboratory (NML) become a National Facility within CSIRO and the establishment of a clearly defined budget.

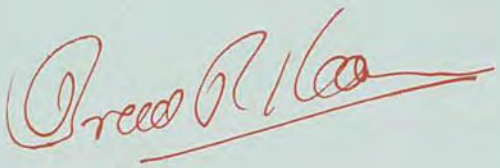
These imperatives require a plethora of activities which are addressed in the four component areas of the Sector Plan, and the Sector Advisory Committee is convinced that this breadth of activity is essential in order for the National Measurement Laboratory to provide the range and competence of support demanded by Australian government, industry and the community.

In addition, the Sector Plan addresses the three areas of challenge set for this Sector in "CSIRO Strategic Research Directions" issued by the CSIRO Executive Committee on 23 September 1996.These challenges covered the requirements for generating external earnings, support and leadership for developing Asia-Pacific measurement infrastructure, and leadership in establishing a system for chemical metrology in Australia. In relation to these challenges, the Sector Advisory Committee draws the CSIRO Executive Committee's attention to two points in particular.

First, the level of external earnings required of the National Measurement Laboratory should be commensurate with its obligations and should recognise the level of resources required for the fulfilment of its legislative responsibilities, its national interest activities and its work to ensure the integrity of the Australian measurement system. Hence the Sector Advisory Committee is concerned that the external funding target of 30% is excessive and does not recognise the opportunistic nature of much of NML's current external income.

Second, the establishment of a system for chemical metrology is a major new activity in which the National Measurement Laboratory would be participating with other infrastructure organisations. The Minister for Administrative Services has indicated some preliminary support for the activities which fall within his portfolio and the Sector Advisory Committee urges CSIRO to seek or identify appropriate funding for the National Measurement Laboratory to play its role in this important activity.

Yours sincerely,



B. R. Kean
Chair, Measurement Standards Sector Advisory Committee

Measurement Standards Sector Advisory Committee:

Bruce Kean (Chair), *Alan Brecht*, Dept of Defence; *Lawrence Cram*, University of Sydney School of Physics; *John Gilmour*, National Association of Testing Authorities Australia; *Chris Nesbitt-Hawes*, Australian Defence Industries Ltd; *Ross Wraight*, Standards Australia; *John Birch*, National Standards Commission; *Rex Christensen*, Australian Telecommunications Authority; *Margaret Fanning*, Dept of Industry, Science & Tourism; *John Hulbert*, Joint Accreditation System of Australia and New Zealand; *Ian Monro*, Testing & Certification Australia

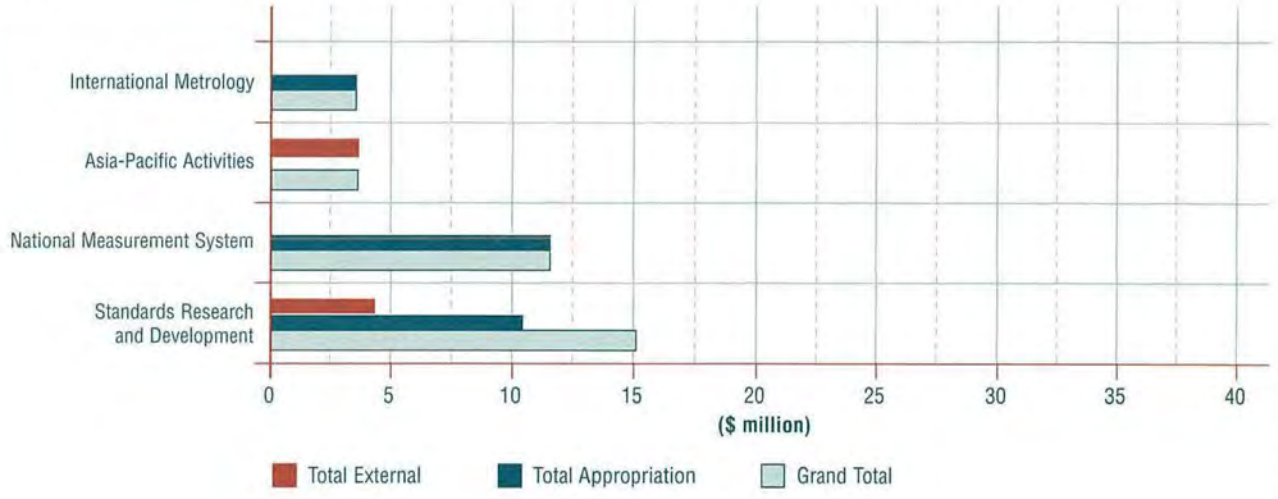
Measurement Standards

Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $33.59 million)

Triennial Investment by Component

(Total Sector Investment $33.59 million)



Measurement Standards

Mission

To assist in the development of Australia by providing standards of measurement to industry, commerce and the community at a level of accuracy equivalent to those of the world's major trading nations.

Overview

The national standards and conformance infrastructure ('the infrastructure') provides the technical basis for orderly commerce, national and international trade, technical harmony between manufacturers, and government regulatory activities. The foundation of this is an effective infrastructure for physical measurement.

Under the Science and Industry Research Act 1949, CSIRO is required 'to establish, develop and maintain standards of measurement of physical quantities and in relation to those standards:

- to promote their use;
- to promote, and participate in, the development of calibration with respect to them; and
- to take any other action with respect to them that the Chief Executive determines.'

In addition, CSIRO is specifically charged by the National Measurement Act 1960 with responsibility for 'maintaining or causing to be maintained standards of measurement for the physical realisation of the legal units listed in the Regulations under the Act.'

CSIRO discharges this responsibility principally through the National Measurement Laboratory (NML) of the Division of Telecommunications and Industrial Physics, Lindfield NSW. The NML maintains primary and secondary standards for:

- acoustics, ultrasound and vibration
- dimensional quantities
- electrical quantities
- hardness
- humidity
- magnetic quantities
- mass and related quantities
- optical radiometry; temperature and viscosity.

CSIRO delegates responsibility for ionising radiation standards to the Australian Nuclear Science and Technology Organisation, Lucas Heights NSW (activity) and to the Australian Radiation Laboratory, Yallambie Victoria (exposure, absorbed dose).

Issues to be addressed by CSIRO

Nationally

CSIRO's statutory responsibilities include:

- maintaining and disseminating standards into industry, commerce, government and the community at appropriate levels of accuracy, and upgrading its measurement capability in response to the development of new techniques in industry
- providing ongoing technical support for other elements of the infrastructure: National Standards Commission (NSC), National Association of Testing Authorities (NATA), Standards Association of Australia (SAA), Joint Accreditation System of Australia and New Zealand (JAS-ANZ), and the Quality Movement (QM)
- representing CSIRO on the management structures of the NSC, NATA and SAA
- providing advice to government departments and agencies on technical issues affecting the infrastructure.

CSIRO must take action in response to the Government's adoption of recommendations made in the *Report of the Inquiry into Australia's Standards and Conformance Infrastructure* (the Kean Report), including

- declaring and operating the National Measurement Laboratory as a national facility
- establishing a clearly defined budget for NML within CSIRO
- in collaboration with other parts of the infrastructure, maintaining and disseminating Universal Coordinated Time Australia (UTCA)
- accelerating the development of chemical metrology in Australia.

Regionally (Asia-Pacific)

CSIRO, through the National Measurement Laboratory, NML, must:

- participate in, and help coordinate, intercomparisons of standards to establish regional measurement traceability
- demonstrate a level of measurement competence and international traceability, sufficient to maintain Mutual Recognition Agreements (MRAs) between Australia and its regional trading partners
- provide technical advice and assistance to support MRAs involving other Australian agencies, e.g. NATA (laboratory accreditation through APLAC), NSC (legal metrology through APLMF), SA (standards writing through PASC), JAS-ANZ (accreditation through PAC)

- provide advice on standards and conformance issues to the Australian Government, to assist it to pursue its trade policies within APEC
- provide technical training and support to regional partners in the areas of measurement standards and calibration services, in support of Government trade and foreign policy initiatives, e.g. AFTA-CER, APEC
- fulfil a commitment to provide the Secretariat and Regional Coordinator for the Asia-Pacific Metrology Program (APMP) for the quadrennium 1994–8
- help to link measurement traceability chains between regional groupings (APMP, NORAMET, EUROMET).

Internationally

CSIRO, through NML, must

- provide the Australian representation at the General Conference on Weights and Measures (CGPM) and participate in the activities of the International Bureau of Weights and Measures (BIPM) in support of Australia's obligations under the *Treaty of the Metre*
- maintain Australia's international reputation as a leader in world metrology by contributing to fundamental research into measurement standards and by regular participation in international intercomparisons of measurement standards.

Strategies and approach

The work for the sector has been divided into four components.

Maintenance of the National Measurement System

Within this component NML discharges its statutory responsibility to underpin the National Measurement System, by:

- providing calibration services for a wide range of quantities, values and instruments
- ensuring that the infrastructure supporting the NML calibration service is adequately maintained
- implementing and maintaining a Quality Management System to a level equivalent to the requirements of ISO 9002 in order to ensure the quality of the NML calibration service
- providing advice to clients on calibration and measurement issues
- supporting other elements of the National Measurement System
- providing training courses in metrology for Australian industry, and in support of NATA.

Standards Research and Development

Within this component NML:

- establishes and maintains Australia's primary standards of measurement, e.g. the volt, kilogram, metre, second. It maintains secondary standards for legal units and values of quantities defined under the Act. It also maintains national standards for other quantities necessary to support the demands of industry and the community
- conducts fundamental research into new-generation primary standards, e.g. the trapped-ion frequency standard and the atomic-based mass standard
- establishes and maintains the NML infrastructure in support of the National Measurement System and in anticipation of the developing needs of industry, for example, standards and calibration facilities for EMC measuring equipment, standard high-voltage impulse dividers and calibration facilities for high-voltage impulse testing equipment, ultrasonic power standards and calibration facilities.

International metrology

This component includes activities in support of Australia's obligations under the *Treaty of the Metre*. Activities include participation in technical consultative committees, the membership of which is drawn from the first-level national standards laboratories.

It also includes participation in international intercomparisons of national standards of measurement to demonstrate Australia's international measurement traceability and competence.

Through these activities, Australia maintains 'Statements of Equivalence' of selected measurement standards with first-level laboratories in USA, UK, Canada, NZ and Korea.

The component also includes participation in international standards-writing committees set up by the International Standards Organisation (ISO) and the International Electrotechnical Commission (IEC) and in international accreditation activities in support of NATA.

Asia-Pacific activities

As one of the few first-level metrology laboratories in the Asia-Pacific region, NML works to improve the standards and conformance capability in developing countries in its Asia-Pacific trading region.

In particular, NML is providing the secretariat and the regional coordinator for the APMP during 1994–98. It also participates in bilateral collaborative programs with the national standards institutes in Indonesia, the Philippines and Vietnam.

Major objectives

Objectives for the 1997–2000 triennium are to

- help maintain Australia's competitive position in international trade, by providing a national measurement system equivalent to those of our major trading partners
- maintain Australia's metrological credibility by participation in international programs to redefine the kilogram and to improve the accuracy of international frequency standards
- initiate a program of research to underpin chemical metrology in Australia by establishing traceability between the mole (quantity of matter) and the kilogram (unit of mass).
- develop facilities in anticipation of new and/or more stringent industrial requirements for measurement traceability, e.g. in electromagnetic compatibility testing
- expand Australia's international intercomparison program, to ensure measurement traceability for all 'key comparison' quantities identified by the consultative committees of the CIPM
- establish a Mutual Recognition Agreement (MRA) in selected standards between all members of the APMP, and between APMP and other regional groupings (EUROMET, NORAMET)
- establish further bilateral programs to upgrade measurement capability in countries in the Asia-Pacific region, with assistance from external funding agencies, e.g. World Bank funding for collaboration with Indonesia.

Customers and technology transfer

Sector customers include the Australian Government; industrial and Defence laboratories with NATA accreditation; State weights and measures authorities, other national standards laboratories within the Asia-Pacific region; manufacturing industry; and service industries.

NML does not compete with NATA-accredited laboratories in the provision of calibration services. While the NML seeks to maximise its external earnings potential, it is not in the long-term interests of the national measurement system for this to be done in head-on competition with other elements of the infrastructure. When it becomes technically feasible and commercially viable for a NATA-accredited laboratory to provide a service, NML helps transfer the expertise to the laboratory and frees its own resources for development of next-generation standards and services.

Marketing and communications

CSIRO's capability and responsibility is marketed through infrastructure publications and seminars and through the Metrology Society of Australia. Briefings on the measurement infrastructure and metrology policy are provided to government ministers and departmental staff.

Development of CSIRO's R&D capacity

Scientific and technological advances planned for the triennium include:

- establishment of an absolute pressure standard facility for Australia
- demonstration of new frequency standards based on the use of trapped ions
- subject to funding, coordination and development of a new system for disseminating Universal Coordinated Time Australia (UTCA), based on satellite time transfer
- completion of the Electromagnetic Interference and Compatibility testing facility
- re-calibration of the 50 kN Avery dead weight force machine.

New or upgraded equipment required within the sector during the triennium includes

	$ '000
absolute pressure standard *	450
caesium clock (x 2)	160
mass spectrometer for chemical metrology *	400
time and frequency equipment	300
Fluke calibrator	70
power-frequency amplifier	60
angle standards	80
10V Josephson array	60
1 kg balance (Avogadro experiment)	140
1 kg Pt/Ir standard	60
CMM controller	150

Major capital items requiring special funding outside component budgets are marked with an asterisk (*). Other items are included in component budgets for the triennium.

Measurement Standards

Succession planning is necessary, with 20 experienced metrologists in the sector reaching age-retirement in the next decade. This requires a continuing program of post-doctoral fellowships in selected areas of standards research, and more emphasis on industrial traineeships and vacation employment for undergraduate students interested in a career in metrology.

Performance and evaluation measures

- client satisfaction with calibration services, with emphasis on rapid turnaround of equipment being calibrated
- repeat contract business from national and international agencies' funding programs to raise the level of standards and calibration services in less developed countries in the region
- maintenance of Australian representation on the CIPM and its consultative committees.

Sector Coordinator

Dr Barry Inglis
CSIRO Telecommunications and Industrial Physics
National Measurement Laboratory
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email: inglis@tip.csiro.au

Divisional participation

Telecommunications and Industrial Physics (93.75 EFT).

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	8.2	8.6	8.9
External funding	2.8	2.6	2.6
TOTAL	**11.0**	**11.2**	**11.5**
External/total ratio	25%	23%	23%

Radio Astronomy

As Chairman of the Australia Telescope Steering Committee I confirm that the Steering Committee has agreed to be CSIRO's Sector Advisory Committee for Radio Astronomy.

The Sector Plan prepared by Prof Ron Ekers, Sector Coordinator for Radio Astronomy, is based on the prioritisation and planning discussions of the Australia Telescope Steering Committee at its annual meeting held on 25–26 March 1996. The proposed budget is essentially the same as that presented in the financial plan of the Australia Telescope National Facility with the exception of the proposed use of CSIRO's capital investment funds. CSIRO capital works funding of the N-S spur of the Australia Telescope Compact Array will facilitate planning of other upgrades to the Compact Array funded by the Major National Research Facilities Program. The addition of the N-S Spur to the telescope array is strongly supported by the Australia Telescope Steering Committee.

Yours sincerely

Dr R L Webster
Chair, Australia Telescope Steering Committee

Radio Astronomy Sector Advisory Committee:

Rachel Webster (Chair), University of Melbourne; *Brian Boyle*, Anglo-Australian Observatory; *Don Melrose*, University of Sydney; *John O'Sullivan*, News Ltd; *Peter Scaife*, BHP Steel; *W (Jack) Welch*, University of California, USA; *Jacqueline Bergeron*, European Southern Observatory; *Dennis Cooper*, CSIRO Telecommunications & Industrial Physics; *Bob Frater*, Deputy Chief Executive, CSIRO; *Hisashi Hirabayashi*, Institute of Space & Astronautical Science, Japan; *Jeremy Mould*, MSSO; *R (Marcus) Price*, OIC Australia Telescope National Facility; *John Storey*, University of New South Wales

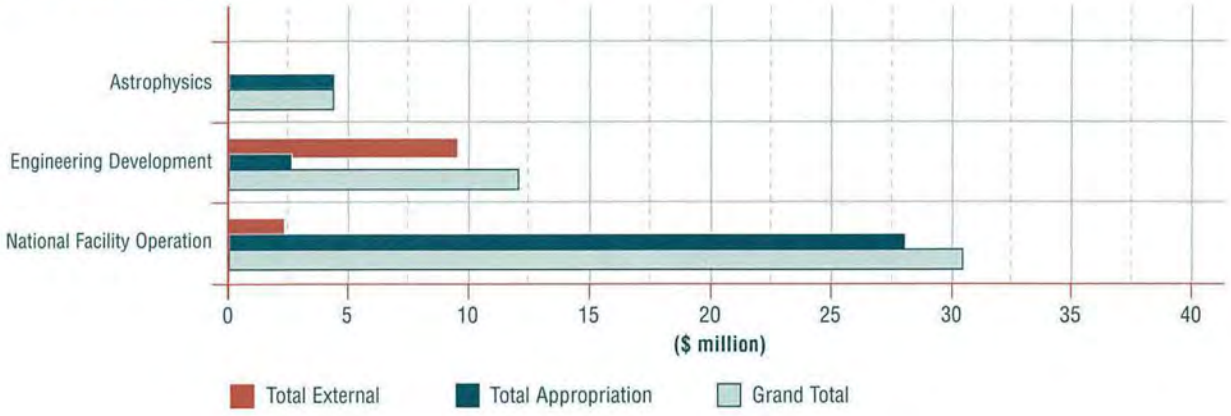
Radio Astronomy

Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $47.17 million)

Triennial Investment by Component

(Total Sector Investment $47.17 million)



Mission

To operate and develop the Australia Telescope as a national research facility for use by Australian and international researchers. CSIRO will exploit its unique southern location and technological advantages to maintain its position as a world class radio astronomical observatory dedicated to the advancement of knowledge.

Overview

Background

As detailed in the Sector Outlook document, 90% of radio astronomy in Australia is performed by the Australia Telescope National Facility (ATNF), so that CSIRO has a leadership role in this field. The ATNF has close interactions with the other significant players operating radio observatories: the University of Sydney, the University of Tasmania, and the NASA Deep Space Network. Users of these facilities are spread over 15 university departments.

The primary goal of this sector is the advancement of knowledge, and it will achieve this over the next 3 years, using three components:

- operating the national facility
- conducting research in astrophysics
- conducting an engineering development program, designed to maintain the ATNF's position as one of the world's leading astronomical facilities.

The ATNF currently operates as a national facility under the guidelines established by the Australian Science and Technology Council (ASTEC) in January 1984. The ATNF Steering Committee is appointed by the responsible Minister and meets annually, to set policy guidelines and establish procedures for allocating time on the facility. Because of the dominant role of the ATNF in Australian radio astronomy, the ATNF Steering Committee was asked, and has agreed, to be the CSIRO Sector Advisory Committee for radio astronomy.

The need for a national facility

Advancement in many fields of science and technology is dependent on a substantial investment in research equipment and facilities. As the necessary equipment and facilities become more complex, they also become more expensive. The cost of establishing and running a research facility rises beyond the reach of individual institutions and requires national or international pooling of funding and other resources. Two years ago, when the government announced a Major National Research Facilities (MNRF) Program, the ATNF was cited as a good example of the type of facility that should be funded under this initiative.

For a national facility such as the Australia Telescope, it is crucial that the astronomy which is carried out should be world-ranking and attract the attention of the international community. There is good evidence that the Australian community has been successful in achieving this: the number of international collaborations involving Australian scientists as well as the large number of excellent proposals to use these facilities by foreign astronomers. In the 1995 Annual Report, the steering committee wrote that 'Such facilities are viable only if they can attract that multiplicity of small teams to get the best out of the instruments. The ATNF has achieved this. The Australia Telescope is used by a criss-crossing network of collaborative teams, national and international, and its observing programs are vigorously diverse.'

Major issues to be addressed by CSIRO

- major astrophysical problems, as listed in the 'Astrophysics Component' Plan, including 'missing mass' and its distribution in the local universe, as well as the nature of quasars
- on a limited appropriation budget, balancing the resources needed to continue operating a first-class national facility against those needed to develop the next generation of technology
- managing the spectrum, so that radio-astronomical needs are protected against commercial interests
- developing its observatory sites, so that CSIRO can capture the full benefit of the MNRF upgrade. For example, the quality of images at 3 mm is, for the current array, critically dependent on atmospheric conditions. Adding a north-south spur, as detailed in the ATNF request for capital investment funds, and summarised in the 'Engineering Development' Component Plan, will enormously reduce this sensitivity to atmospheric conditions and so enhance the science that will result from the MNRF upgrade.

Potential value to Australia and CSIRO of addressing these issues

- Australia maintains its high profile in the international science community
- the ATNF provides an impressive international showcase of Australian technology
- accessible sciences like astronomy attract young people to science

- basic science is a 'leading-edge' customer of Australian industry. For example, the ATNF continually benchmarks against international best practice
- access to the ATNF by overseas researchers ensures that Australian researchers in other fields continue to be granted access to overseas national facilities.

Strategies for the next triennium

- continue to encourage innovative and leading-edge research programs
- constrain the scope of national facility operation to remain within sustainable base-level funding
- fund technology development and future instrumentation from external funding
- continue to pursue collaborations with other leading astronomical institutions
- focus ATNF development on areas where it can excel on the international scene
- stimulate science education and public science awareness.

Strategies for beyond 2000

Australia is well positioned to play a major role in radio astronomy, both for historical reasons and because of its Southern-Hemisphere niche. Past investment means that our national facilities such as the ATNF are among the world's best, and so provide a lever to gain access to other international facilities. By continuing to invest resources in them, we can maintain them at the cutting edge for the next 5–10 years. Within the next 10–20 years, new internationally funded observatories, costing hundreds of millions of dollars, will be needed. Since all such facilities require a Southern Hemisphere component, Australia is well placed to play an advantageous role in developing these facilities. However, to do this, we need to conduct strategic research now, in relevant technologies such as millimetre arrays, large-scale arraying, and interference excision.

Outline of external consultations

Operations and future developments are guided in consultation with:

- the ATNF Steering Committee, which also functions as the Sector Advisory Committee. Its membership includes four Australian astronomers (three of whom are non-CSIRO), three overseas experts, two industry representatives, four ex-officio members (Deputy-Chief Executive of CSIRO, Director ATNF, Chief of CSIRO Telecommunications and Industrial Physics, and the Director of the Anglo-Australian Observatory). For the duration of the MNRF upgrade, it will also include an ex-officio representative from the University of Tasmania. The Chair of the committee is chosen from non-CSIRO members
- the ATNF Time Assignment Committee, appointed by the Steering Committee to allocate research time on the facility
- the ATNF User Committee, appointed by the Steering Committee to represent the user community
- external users of the ATNF, who typically visit the facility for a few weeks at a time to conduct observations and analyse data. The ATNF takes maximum advantage of this to obtain feedback from, and build up relationships with, these users
- overseas scientists who stay for extended periods under the ATNF distinguished visitors program
- other eminent scientists elsewhere in the world, who are consulted as appropriate.

In addition, the ATNF maintains a large number of astrophysical collaborations between its own scientists and those in other institutions, both in Australia and overseas.

Major objectives and key potential outcomes

- maintain the ATNF as a world-class radio-astronomical facility, as measured by demand and output
- advance knowledge in the field of astrophysics, including at least 100 papers (based on data acquired with ATNF facilities) published each year in international journals
- develop appropriate cutting-edge technology so that Australia can play a major role in the next generation of radio-astronomical instrumentation
- continue to maintain a public and high-quality profile for CSIRO.

Customers, technology transfer and commercialisation

External clients and customers

In the last five years the ATNF has expanded its user community from 400 to 800 users. The total number of institutions using the facility has increased from 42 to 97 (15 of which are Australian). In-house CSIRO use has dropped from 45% to 25%, as is appropriate for a national facility.

CSIRO manages a national facility which has 'advancement of knowledge' as its primary goal, and the CSIRO Executive consider it inappropriate for the ATNF to have an external income target. However, the ATNF Steering Committee recognises that opportunities with net scientific benefit to the national facility can arise, which are consistent with the ATNF's mission. In these cases the committee supports initiatives which generate external income. Recent examples of such opportunities are given in the Sector Outlook, and our estimated external income for the triennium is 26%.

Australian radio astronomy maintains active links with many other international astronomical institutions. In particular, the ATNF has strong active collaborative projects with institutions in the USA, Netherlands, UK, Japan, and China.

Links between ATNF and universities

There is a strong interaction between the ATNF and Australian universities, of which the staff and students account for a large proportion of ATNF users. ATNF staff supervise about 33 PhD students, and frequently give talks to undergraduates and other university groups. Many university staff are on the various ATNF committees, and ATNF staff are represented on several university committees. Many collaborations exist between ATNF and university staff and students, including significant joint engineering developments. There are also several joint appointments between the ATNF and the universities.

Impetus for technological innovation

Leading-edge customers are needed to drive innovation, and scientists performing basic research on a facility such as the ATNF are very effective leading-edge customers. Radio astronomy has a proven track record of generating this innovation. Examples include satellite downlink antenna and feed design, the Interscan aircraft landing system, and focal-plane arrays. A current example is the ATNF's collaborative project with the CSIRO Telecommunications and Industrial Physics (CTIP) to produce cryogenic monolithic millimetre integrated circuit (MMIC) receivers for wavelengths down to 3 mm.

Technology transfer

The ATNF must maintain its position as an internationally competitive facility. This requires it to develop technical expertise in a number of areas where there is little or no industry support. These include cryogenic RF systems, antenna design (with CTIP), high-speed digital hardware and real-time control, and imaging software. Whenever possible the ATNF will transfer any technology developed to Australian industry.

Commercialisation strategy and management of IP

Technology transfer is achieved through development projects with Australian engineering companies and with CTIP. As is appropriate for a national facility dedicated to the advancement of knowledge, the ATNF does not normally attempt to commercialise the results of research, although technical developments are sometimes commercialised, often in collaboration with CTIP.

Marketing and communication

Marketing to national facility users is described in the 'National Facility' Component Plan. Equally important is public communication, in which the ATNF has, and will continue to maintain, a high public profile. Radio astronomy is promoted through:

- radio and television interviews, and press stories featuring the ATNF or its staff (an average of more than 50 a year)
- visitors' centres attached to the Parkes and Narrabri observatories, which attract about 100,000 visitors each year
- talks, to school groups and others, and to the general public (about 20 a year)
- information packs for school children
- participating in the work-experience program
- observatory open days
- other live events, such as science festivals.

In addition, an important part of the ATNF's goal is to help educate Australia's young people about science, and attract them to it. ATNF staff supervise about 33 PhD students, and give talks to undergraduates and high-school students. In addition, each summer the ATNF runs a vacation scholars program, in which about 10 vacation students each spend two months working on scientific or technical projects under the supervision of an ATNF staff member.

Development of CSIRO's R&D capacity

Summary of anticipated scientific and engineering/technology advances

CSIRO will:

- discover many new galaxies in the local universe, as a result of the multibeam survey
- conduct a VLBI survey to select southern compact radio sources in readiness for the VSOP mission

- develop a better understanding of the nature and emission mechanisms of star formation, pulsars, supernova remnants, galaxies, and quasars, as detailed in the Astrophysics Component Plan
- develop GaAs HEMT and MMIC technology for 3 mm and 12 mm wavelengths
- develop atmospheric phase measurement and correction techniques
- develop new local oscillator systems for the Compact Array, including wide-band optical fibres
- develop multibeam feeds and focal-plane arrays
- develop interference excision technology
- develop algorithms and visualisation techniques for data analysis, particularly for multi-dimensional data cubes
- develop new software packages including ATOMS and aips++.

Investment in scientific and engineering opportunities and development of the skill-base

CSIRO must:

- develop expertise and collaborations in millimetre wavelength astrophysics to take advantage of the completed millimetre MNRF upgrade
- develop better links and more collaborative projects with optical and space astronomy to take better advantage of new opportunities to complement the radio facilities
- develop object-oriented software engineering technology
- develop millimetre-wave engineering and MMIC technology
- develop high-speed electronics technology
- develop focal-plane array technology.

Performance and evaluation measures

Keys to achieving success for internal coordination and management purposes

CSIRO must:

- maintain a stimulating research environment which maximises cross-fertilisation of ideas and techniques
- develop a flat management structure
- maintain structures which enable close interaction and consultation between ATNF staff and the user community
- make extensive use of Internet, Intranet, WWW, and distributed databases.

Performance indicators

- observing time successfully completed as a proportion of total scheduled observing time
- shift of resources according to priority decisions agreed with the user community
- adoption by users and organisations of practices, instruments, and processes developed by CSIRO
- the number of external users of ATNF facilities, consistent with ATNF's mission
- level and quality of publications, including number of publications, and citation rates
- teaching, measured by number of postgraduates supervised by ATNF staff
- public communication, measured by number of media appearances and talks to schools and community groups.

Sector coordinator

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Director, Australia Telescope National Facility
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Divisional participation

Australia Telescope National Facility (33 EFT), COSSA (1 EFT).

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	11.7	11.6	11.7
External funding	4.7	4.2	3.2
TOTAL	**16.4**	**15.8**	**14.9**
External/total ratio	29%	27%	22%

Proposed Capital Investment Funding (see Engineering Development Component for more detail)

Total ($ million)	0.7	1.6	0.5

Services

The CSIRO Services Sector Advisory Committee, consisting of some fifteen members representing the service industries, met on two occasions in 1996. The areas studied were confined to: health services; imaging; data mining; security systems; and decision support for services process improvement. On 18 December 1996, the Committee's report was forwarded to the CSIRO Chief Executive.

Final recommendations were based on the CSIRO priority criteria resulting in health services, imaging and data mining being given the highest priorities, with security systems rating well and decision support for service process improvement receiving mixed results. The priority criteria used, while providing a reasonable consensus can introduce problems associated with possible bias and lack of knowledge amongst the committee members and thus a low rating may not necessarily indicate that an area should be deleted from the program.

The security systems element is a relatively new area of research and although it has high potential, it is important that this be closely monitored to ensure it is of real industry interest and value. It is important to realise that while imaging and data mining exist in their own right, they are also involved to a large extent in the other elements of the study and this should be considered when final decisions are being made.

Thus, it is recommended that at this stage, in each area, performance targets be developed based on costs and results, and these be carefully monitored over a period of some months with a further review in late 1997. More definite recommendations and strategies will then be developed.

Finally, the committee felt that the potential for development in the services sector is such that CSIRO should consider increasing its funding, provided it can be demonstrated that this can genuinely contribute to the substantial development of the appropriate enterprises with ultimate results at world standard levels.

Peter O'Grady
Chair, Services Sector Advisory Committee

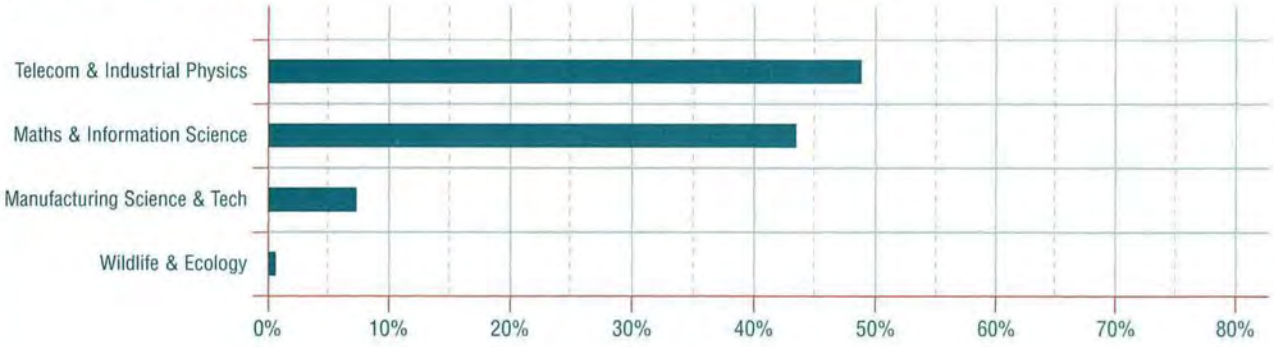
Service Sector Advisory Committee:

Peter O'Grady (Chair), Quality Consultant; *Tony Adams*, Dept of Health & Family Services; *Garry Campbell*, Coles Myer Ltd.; *Carmel Cray*, Logica; *Judith King*, Australian Coalition of Service Industries; *Michael Mannington*, ID Tours; *Roger Nairn*, National Australia Bank; *Seong Who Choo*, National Roads and Motorists Association; *Victor Skladnev*, Polartechnics

Services

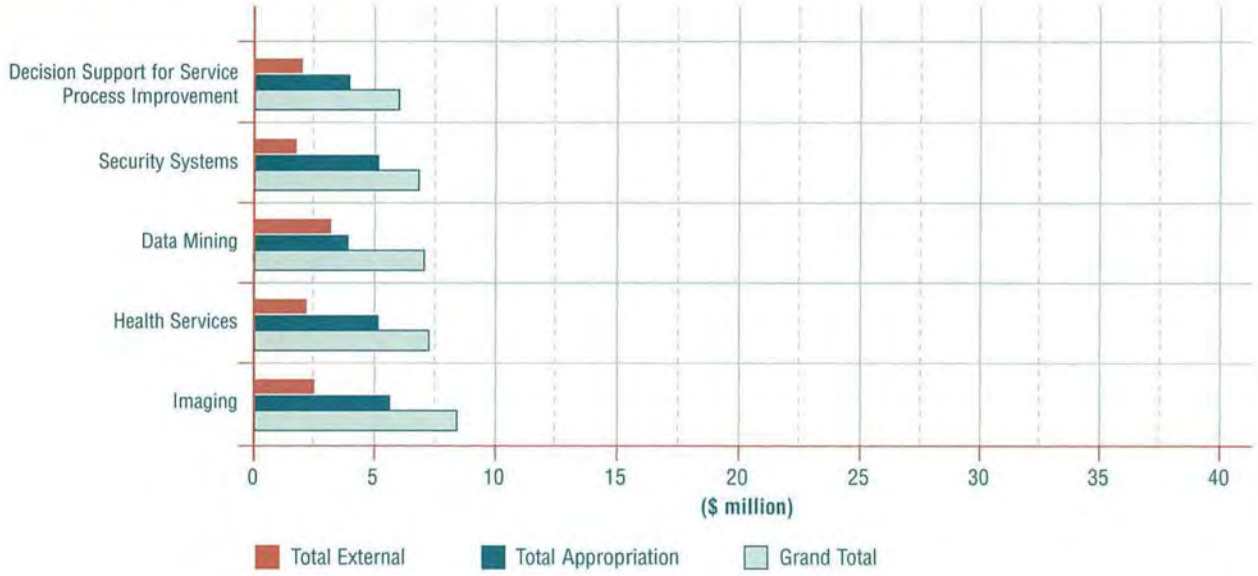
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $35.81 million)



Triennial Investment by Component

(Total Sector Investment $35.81 million)



Mission

To develop and deploy methodologies to enhance the organisational performance of services sector enterprises, by facilitating the creation, management, access to and use of information for effective decision making. CSIRO will continually enhance the knowledge base from which these products and services have been created to ensure that it can meet the longer-term needs of its customers and the nation.

Overview

The Services Sector

The Services Sector is immature with respect to R&D. CSIRO's interactions with the sector, until now, have been somewhat limited. CSIRO should adopt an exploratory role over the next triennium. Initially it will focus on health services and security systems, but it will be important to develop other research areas during the triennium. CSIRO must carry out significant tactical work to establish credibility, build relationships and provide feedback to inform the development of the strategic base.

Services form the largest component of the economy in all industrialised nations. Services are now a significant part of world trade—21.2% in 1994, exceeding the combined value of exports of agricultural and mining products. Australia currently enjoys a $2.8 billion trade surplus in services.

The sector is increasingly competitive and global. The development of IT-based on-line services raises the possibility of global service provision with less need for local bases. This provides very large threats and opportunities for the Australian services sector. As services constitute major inputs to all other parts of the economy, efficient delivery will contribute significantly to the nation's well-being. Although services have a low R&D intensity, a substantial and increasing amount of R&D is being carried out, particularly in those services being opened to competition. R&D is seen as providing a competitive edge in the sector.

Australia's services sector comprises about 45% of the national economy and is growing at the same rate as the economy as a whole. News Corp, NAB, Westpac Banking, Commonwealth Bank, ANZ Banking Group, Coles-Myer and Lend Lease are listed among the world's top 1000 companies. Service sector exports now comprise 13.8% of Australia's total exports, with tourism and educational services the main components.

The ability of services sector companies to capture the benefits of R&D has been well documented internationally (Citibank, Walmart, Sainsburys are prominent examples). The Australian industry will need to significantly increase its commitment to R & D to remain competitive. The international competitiveness of the sector is shown by the increasing trend in the services trade surplus and significant R&D investment. Deregulation and the increasingly global marketplace for services will reinforce this trend. The sector-alliance process makes it feasible, for the first time, for CSIRO to contribute significantly to the technological underpinning of Australia's services industry, the prosperity of which is critical to the nation's future.

The Services Sector embraces activities related to the provision of services including wholesale and retail trade, finance and insurance, property and business services, health services, education and training, community and public services, recreational and other commercial services (including travel, tourism and commercial security). Service functions are widespread in all sectors of the economy—for example, warehousing and distribution within a manufacturing firm. The sector includes generic service functions regardless of sector of application.

Major issues for CSIRO

CSIRO is uniquely placed to tackle R&D at the system level for service functions. Unlike other groups in the public or private sectors, we are able to assemble teams to tackle Services Sector problems, many of which arise in the sequence:

data capture–data analysis and interpretation–information for decisions

The technology challenge arises from the difficulties encountered in capturing suitable data or sufficient data, and the requirement for rapid interpretation to aid timely decision making.

There are also challenging problems that arise in enabling access to information about products and services, and in modelling complex systems to guide the sequence of capture–interpret–decide. In Australia this capability exists only in CSIRO.

Most R&D carried out by service organisations is heavily biased towards development, with a preference for off-the-shelf technology and customisation to meet specific needs. CSIRO needs to build links with the suppliers to these firms, perhaps through consultancies, and carry through projects to the prototype phase.

External consultation

There have been two meetings with the Sector Advisory Committee and a number of off-line discussions with members of the committee. The committee has evaluated all of the component research activities, using the

CSIRO research priority framework for making comparative judgements. There were significant differences in the rankings supplied by different members of the committee and these reflected, in part, their different industrial perspectives.

Their analysis suggested strong support for the component research plans in health services, imaging and data mining. Support for security systems was at a lower level, reflecting the need for focused projects and careful monitoring. Despite strong support from several members of the committee, the median attractiveness/feasibility ratings for the 'decision support for service process improvement component' placed it in the lower left-hand quadrant. Committee members were keen to see project selection sharply focused and selective, with careful monitoring of outcomes.

Major objectives and key potential outcomes

- **Develop and deploy methodologies** for the improvement of service processes, based on the effective use of data and information and on models for the optimal allocation of resources in service process delivery. The outcomes will be improved quality and productivity in service processes.
- **Develop an integrated capacity** to manage, explore, summarise, model, analyse, and interpret large and complex datasets in order to identify valuable patterns, trends and anomalies. Apply these methods to large and complex datasets arising in health services, tourism, financial services, retail trade and tourism, to achieve better decision making and significant cost reductions.
- **Develop generic technology** and functioning systems for:
  - — image forming systems
  - — high speed real-time image processing systems for object identification, detection and tracking
  - — image data manipulation, storage, transfer, retrieval and analysis.
- **Apply these methodologies** and systems in a wide range of applications to achieve:
  - — higher levels of productivity in infrastructure management, and
  - — significant cost reductions in medical diagnosis, improved safety through effective mine detection and shape measurement.
- **Develop information-based and expert systems** for the effective capture, modelling and interpretation of data arising in the health care system, to enhance the cost-effectiveness of service delivery processes.
- Develop technology and systems for use in the security industry and security applications arising in the sector for identification, recognition and verification of individuals and objects in security-critical activities such as passport control and access to computer systems and ATMs. Expected outcomes are:
  - — safer and more accurate security systems
  - — an enhanced competitive position for local providers
  - — increased ability to avert major security breaches and their potentially tragic consequences.

Customers, technology transfer and marketing

Customers and stakeholders include service organisations such as NRMA, the Credit Reference Association of Australia, RACV, Fuji-Xerox, RTA, Australian Passports Office, State and Federal Police, Departments of Immigration and Ethnic Affairs, Department of Customs, the Sydney Organising Committee for the Olympic Games (SOCOG), security companies, departments of health and hospitals, ultrasound and medical imaging providers (including Polartechnics), FAC, Health Insurance Commission, and a number of CRCs.

There are also companies in non-service sectors with which the sector collaborates on R&D related to service functions (among them AIP, ICI Explosives, MIM, Arnotts Biscuits, AE Bishop & Co, Telstra, Kodak). Some work in the sector will be aimed at SMEs as a class.

The Services Sector has developed a sector marketing process which it believes will provide a model for a sector-based approach to marketing throughout CSIRO. The approach is intrinsically sector-based, with no competitive division-based marketing to the sector.

The process consists of seven stages:

- — identify trends
- — define opportunities
- — ensure world-class capabilities are identified
- — promotion
- — services delivery
- — review
- — feedback

Key aspects of this process are:

- The sector advisory committee and a broadly-based group of customers will be involved in the identification of licences and needs (this process also requires technical input).
- Professional marketing staff will be involved in the preparation and presentation, to sector technical staff, of trend information and opportunities.

- CSIRO will develop a shared understanding of its technical capability, its relevance to the sector, and any gaps which must be filled to meet customer needs (flexibility is also important in this context).
- Marketing and technical teams will be involved in promotion. They will target appropriate companies in the sector with key account management, sector-based communication, and information systems support.
- Service delivery is a critical aspect of any sound marketing system—CSIRO will base its service on a high level of customer focus.
- The process loop, which should be recognised as being dynamic and unending, will include review and feedback.

Development of CSIRO's R&D capacity

These issues are dealt with more fully under the individual component research plans, but may be summarised as:

- development of strong synergies between the technologically focused components in relation to the system level problems of health services
- further development of strong links between the technologies within the imaging component
- development of a world class technology base in data mining, particularly in regard to the analysis of large, complex datasets, dynamic visualisation and methods for cleaning databases
- continued development of world class technologies, including face recognition, video capture and processing and compression and deployment in security services
- increased focus on integrated product development in data capture and interpretation for management
- further development of outstanding capabilities in operations research (for example, in rostering) for deployment in the services industry context.

Performance and evaluation measures

In view of the sector advisory committee's requirement for demonstrated focus and outcomes, especially in two of the components, development of effective performance measures will be a priority activity for the sector in its activities for next year. Individual component research plans list their specific performance measures, which are broadly in line with CSIRO's performance indicators.

Sector coordinator

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Divisional participation

Mathematical and Information Sciences (36.6 EFT), Manufacturing Science and Technology (6.0 EFT), Telecommunications and Industrial Physics (36.3 EFT), Wildlife and Ecology (0.7 EFT).

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	7.9	7.9	8.2
External funding	3.5	3.9	4.4
TOTAL	**11.4**	**11.8**	**12.6**
External/total ratio	31%	33%	35%

Chemicals and Plastics

The Chemicals and Plastics industry is a major contributor to the Australian economy, responsible for a market of over $28 billion, and the employment of about 100,000 people. The liberalisation of trade around the world and Australia's geographical isolation point to the need for firms operating in Australia to develop a competitive advantage which is either knowledge based or takes advantage of Australia's natural resources.

CSIRO can play a key role in developing competitive advantage through its potential to develop an underpinning strategic role in supporting the Australian industry. CSIRO research in areas such as specialty chemicals, polymers and cleaner production and disposal have shown appreciable returns on investment with the expectation of greater returns in the future.

The Sector Advisory Committee (SAC) provides a valuable mechanism by which CSIRO can enhance its relationship and alignment with the Australian chemicals and plastics industry. It will do this by:

- facilitating closer relationships between CSIRO research and industry as a result of better understanding of industries development needs and of CSIRO's capabilities.
- providing input on current and future industry directions
- contributing to the planning process
- overviewing program implementation

As a consequence, the SAC mechanism should provide the CSIRO with a valuable tool for priority setting and resource allocation. This has already been demonstrated in relation to inorganic chemistry, where it was agreed there was little need for skill enhancement in CSIRO, and in the production of chemicals from natural gas where the SAC has been asked to examine opportunities for CSIRO to contribute, for example in reducing fertiliser imports.

The Committee will also assess CSIRO's role in relation to supporting small and medium sized companies, in order to identify an appropriate customer base and enable CSIRO to exercise maximum leverage in this area.

A major priority of the SAC will be to determine how CSIRO in partnership with industry can assist in developing a national chemical industry strategy.

Alan Seale
Chair, Chemicals and Plastics Sector Advisory Committee

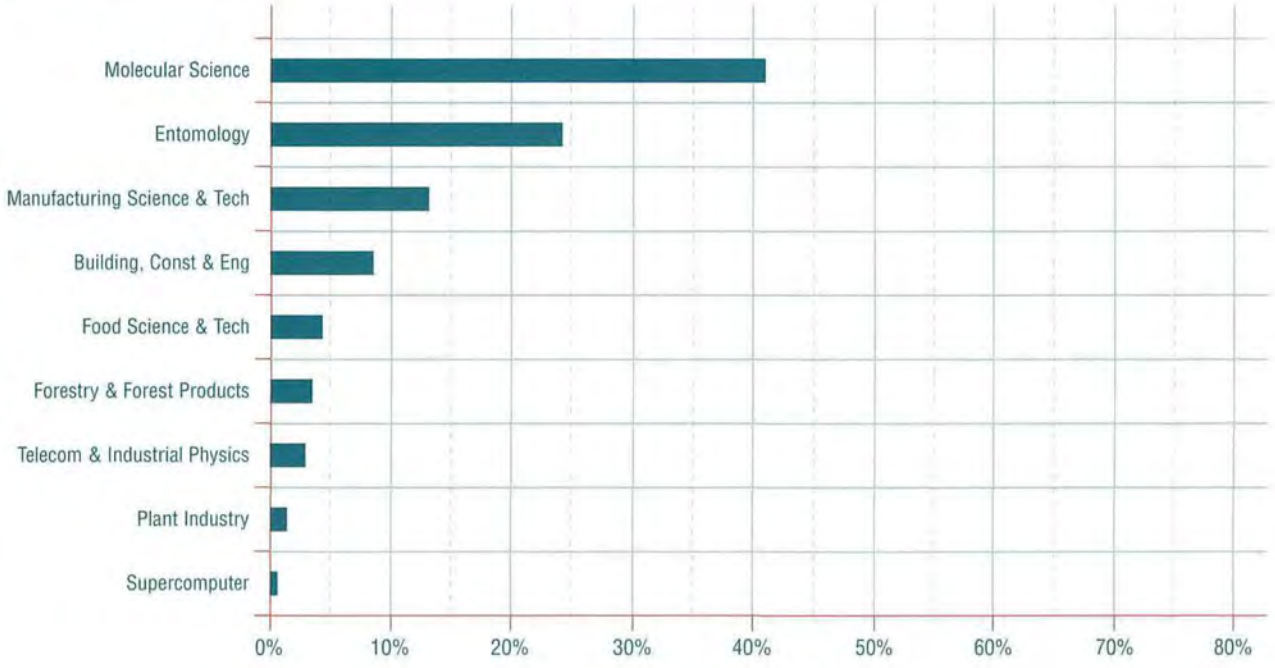
Chemicals & Plastics Sector Advisory Committee:

Alan Seale (Chair), ICI Australia; Doreen Clark, Analchem Bioassay; *Bev Clarke*, Dept of Industry, Science & Tourism; *Leo Hyde*, Du Pont Australia Ltd; *Roger Karge*, ITL; *Michael MacKellar*, Plastics & Chemicals Industries Association; *Ian Rae*, University of Melbourne; *Greg Rappo*, Abbott Laboratories; *Doug Rathbone*, Nufarm Pty Ltd; *Claude Gauchat*, Avcare

Chemicals and Plastics

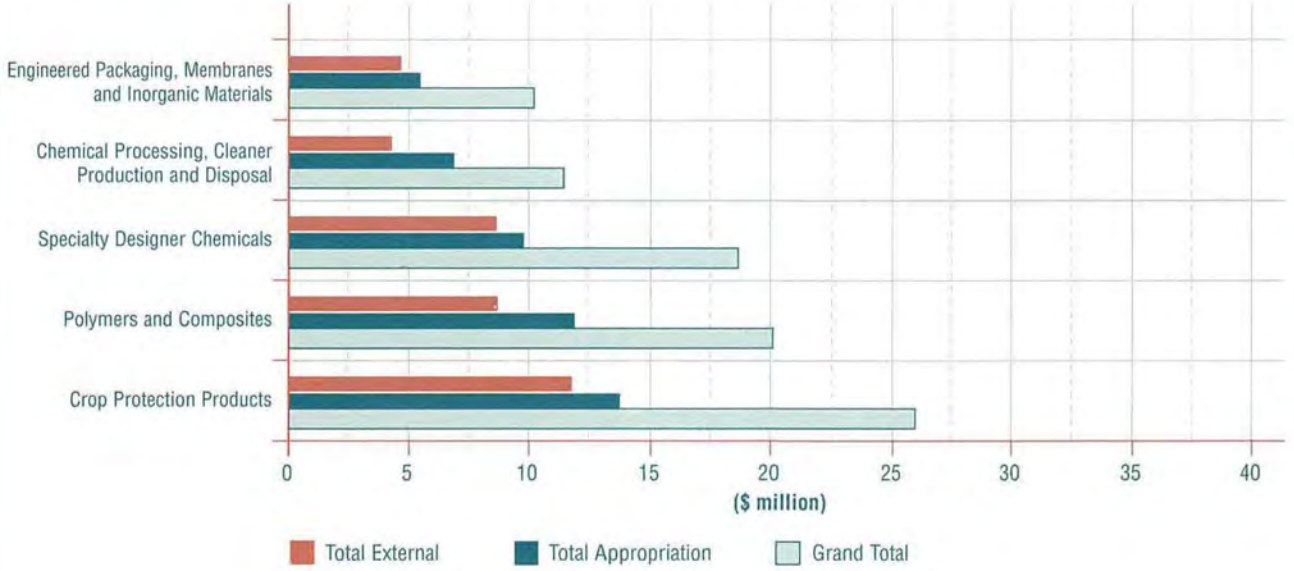
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $84.81 million)



Triennial Investment by Component

(Total Sector Investment $84.81 million)



Chemicals and Plastics

Mission

To work with enterprises involved in the application of chemical, biochemical and polymer technologies in projects which aim to generate economic, social and environmental benefits for Australia.

Overview

Major issues

The Australian chemical and plastics industry is undergoing structural change following tariff reductions over the past decade and now has a much stronger international focus, with a broader industrial base. It comprises more than 30 companies with an annual turnover of more than $100 million, and thousands of smaller specialist plastics and chemicals producers. Most of Australia's industrial operations are not large on a world scale—local companies are generally better able to compete internationally in niche areas than in commodity products.

CSIRO recognises the 'chemical trade deficit' of some $6 billion as a major concern because of the importance of the chemical and plastics industry to many downstream sectors. CSIRO is active in coordinating a response which will take advantage of this issue and are aware of the opportunities it may generate. Other notable opportunities arise from meeting the special needs of 'leading-edge customers' in other industry sectors.

Environmental, health and safety concerns combined with stricter government legislation provide a number of opportunities for CSIRO in 'clean' chemical manufacturing, waste disposal and safer products.

Potential value to Australia and CSIRO of addressing these issues

The chemical and plastics industry underpins Australia's manufacturing industry. It is a supplier of input materials to the agribusiness and manufacturing sectors of the Australian economy, and a supplier of products direct to domestic consumers. The industry has a predicted growth of 3% to 5% pa. It features a number of multi-national companies and a large number of small to medium-sized companies, which together contribute significantly to Australia's manufacturing performance and provide strong employment capacity.

Australia's manufacturing industries, particularly those producing high-value materials, are increasingly contributing to the wealth of this country. This sector includes the burgeoning non-medical biotechnology industry, which produces crop protection, specialty and environmental products.

One of the strengths of CSIRO in this sector is its research in the pesticide area. Classified with pharmaceuticals by Syntec in their *Guide to Growth* (1996), exports of pesticides are predicted to grow by 9.6% a year on average over the next six years. CSIRO research in this area is sought after by major multinationals. With links to a strengthening domestic production sector, CSIRO can exert leverage on behalf of Australian industry and public interests.

There are demands for new products that are safer and more environmentally friendly, and which overcome pest resistance. In this perspective, the balance between engineered biological pesticides ($1.4 million a year), non-engineered biological pesticides ($1.6 million a year), and chemical pesticides ($2.3 million a year), reflects the way markets are predicted to develop rather than the current market share for chemicals (98%).

It is a characteristic of this sector that the largest producers in terms of volume and value introduce technology slowly—large cycle times are required to allow full benefit from commercialised technology.

Environmental concerns are a major driver in industry and a significant number of current projects address this issue. Cleaner, safer and more efficient products and processes, which are more accurately targeted to their application, provide significant economic and environmental benefits and also enhance the environmental reputation of CSIRO and Australian industry.

The overall strategies and approaches

CSIRO has close interactions with the chemicals and plastics industry and is very active in developing an understanding of the industry, as well as influencing its strategic directions. It will develop and maintain research in selected areas of this sector to complement Australian industry.

CSIRO recognises the need to remain scientifically literate across the main sections of the sector and will expand its effort in the specialty chemicals area. Current projects are in most cases committed over several years. CSIRO will continue to identify the strategic areas that it should develop to meet the challenges of the future. For example, it is clear that high throughput chemical synthesis and biological screening will play a large role in future research in the area of biologically active chemical research. Expertise developed in clean chemical processing and waste disposal will also be maintained. Genetic engineering of single genes and simple organisms will be an increasingly important route to creation of high value products, as well as an adjunct to the discovery of more traditional chemical products.

Chemicals and Plastics

CSIRO will continue to develop its knowledge of fundamental chemical and biological processes to exploit emerging trends in chemistry. Increased understanding of chemistry at the molecular level is necessary for better design of chemicals and materials with required properties. CSIRO will need to look at methods and opportunities to increase collaboration between chemists, molecular geneticists and biologists to maintain its position in world research.

The increasing sophistication of the required equipment for competitive research is a major issue in this sector. The high cost of state-of-the-art equipment, and the increasingly short time until the equipment becomes out of date, means that few research institutes are able to fund all the required instrumentation from their own resources. This has been overcome, in chemistry and biology, through sharing the cost of instruments. While this is not ideal, developments in information technology have allowed much more effective data processing and sharing than in the past. The physical location of the instrumentation is thus less important than it was previously. CSIRO's intention is to maximise use of equipment by making it available to other relevant areas of the organisation and by jointly acquiring and operating very expensive equipment with universities and industry.

Studies will be undertaken to assess the balance of effort in support of different product categories. For example, CSIRO is currently identifying international and Australian customers of crop protection chemicals, to determine the best balance of chemical and biological discovery effort and technology implementation.

To ensure an optimal skill base for inorganic chemical applications in Australian industry CSIRO initiated an extensive review of present skills and current and potential applications in Australia. The report was completed in early 1997.

Enhanced understanding of the structure and makeup of the chemical and plastics industry will identify gaps in integration with downstream industries. This may provide opportunities for CSIRO to contribute to the downstream production of organic chemicals from natural gas feedstocks and reduce targeted bulk imports (e.g. fertiliser).

The Chemicals and Plastics Sector in Australia is one of the most research intensive parts of Australian industry. CSIRO's role depends on whether we are dealing with large multinationals, large local companies, or small to medium-sized companies (SMEs). For the latter, CSIRO can act as an information resource, as a provider of high-level analytical skills, and as a source of new products and innovative processes.

CSIRO will build on its current knowledge and support of SMEs in the Chemicals and Plastics Sector in order to identify those best able to benefit from its technologies.

Outline of external consultations

A number of staff are represented on chemical industry associations and working groups.

Six-monthly meetings of the Sector Advisory Committee will provide guidance as to how and where in the sector CSIRO can best make its contribution.

The organisation will be providing information on the technology base of the Chemicals and Plastics Sector in a forthcoming analysis of the industry.

Major objectives and key potential outcomes

Crop protection products

- develop new bioactive chemicals for use as environmentally safe herbicides, insecticides and fungicides
- develop engineered and non-engineered biopesticides for insect control in Australia and overseas
- manage and support chemical, plastic and biological products for the control of insects
- develop protein-based technologies for the management and clean-up of pesticides.

Polymers and composites

- develop an advanced composites industry and support the existing commodity composites industry
- develop novel methods of engineering the surface of polymers for controlled adhesion and interface/interphase performance, and to investigate their application in automotive, bio-medical, construction and composites industries
- increase the productive use of fertilisers by controlled release of nitrification inhibitors
- develop advanced diagnostics, modelling and recycling procedures to enable optimal polymer life.

Engineered packaging, inorganic materials, and membranes

- deliver advanced packaging materials suitable for the Australian packaging industry that will allow, through extending the shelf life of products, the delivery of fresh Australian food products to international markets

- develop processing methods to deliver specialty designed chemical powders to Australia's chemical and manufacturing industries.

Specialty designer chemicals

- develop surfactants based on renewable resources, to improve their function in household and industrial products and processes, and to investigate their application in opto-electronic devices and biosensors
- develop security devices for the coding, storing and authentication of information based on concepts involving photochemical and photophysical principles
- develop novel methods for manufacturing plant gums and other plant biopolymers for use as gelling agents, thickeners and emulsifiers in cosmetics, health-care products, agricultural products and industrial products. To identify preferred applications for these biopolymers
- produce novel industrial fatty acids from renewable plant resources
- provide a centre of excellence in bio-based composites
- develop a new environmentally friendly system for rayon fibre manufacture
- develop fast curing high efficiency wood resins
- develop novel chemicals for wood protection.

Cleaner production and disposal

- research the manufacture of high value chemicals in Australia using new processing methods which are more efficient and environmentally sound
- generate a portfolio of CSIRO owned technologies and expertise in the area of cleaner production and waste disposal using combinations of microwave, membrane and plasma technologies.

Customers, technology transfer and commercialisation

The anticipated clients and users of the research results

A diverse customer base comprising various sized multinational and local companies who are manufacturers and downstream users of chemicals and plastics.

Some current clients are:

Large companies: DuPont, Hoechst, ICI, Zeneca, Pratt Industries, Pacific Dunlop, CSR, Telstra, Alcoa, Abbotts, Venture Industries, American Home Products.

SMEs: Macfarlane Industries, AMRAD, Fauldings, Squalus, Holden Special Vehicles, Borden Chemicals, Huntsman Chemical, Panbio, Marplex.

Technology transfer–commercialisation strategy–management of IP

Crop protection products

CSIRO has a strong research base in all the key disciplines in this area for the discovery phase, and needs to work closely with companies for the development of products. The sector approach has allowed for some consolidation of effort which will enable greater external earnings. CSIRO projects in this area are all aimed at more closely targeted products, produced by cleaner processes.

Demand for clean green pest control will drive an increased market share for biological pesticides, rising to 25% by 2020, as well as safer chemical pesticides. CSIRO's high profile with leading-edge customers allows it to build strategic alliances with, and between, local manufacturers and multinationals. International efforts in this area are emphasising both the need for greater understanding of the biology of pests, as well as the need for high throughput synthesis and screening of new chemical entities. It is in the latter area that we will increase our investment.

Polymers and composites

CSIRO is Australia's dominant R&D performer in this area and has both public and industry collaborators, so that its effort here is likely to expand. Polymers are a key material for the future because they can often provide cheaper, safer, more energy-efficient, environmentally acceptable and durable alternatives to existing materials. The expansion will be industry funded with our industrial partners attracted by the better integration of the science and engineering skills across the sector.

Engineered packaging, inorganic materials and membranes

Here CSIRO is targeting the Australian food packaging industry with smart, biodegradable plastic materials. These products also offer considerable export potential. CSIRO will continue its leading role in the molecular design and manufacture of inorganic materials. It will continue to work in the areas of preparation technologies (particles, paint pigments etc), biosystems engineering and microsystems engineering. The level of effort will be increased by 25% over the next triennium as a result of the expected increase in external income and redistribution of effort within the Division of Manufacturing Science and Technology.

Specialty designer chemicals

This area is considered a growth area in the economy. CSIRO has the opportunity to position itself as a key provider for domestic and international leading edge customers. CSIRO is the only public researcher in this area in Australia. This is the area in which the Sector Advisory Committee recommended expansion. It is an area with high SME involvement, and good opportunities for the adoption of locally developed technologies.

The customer base and markets are diverse requiring CSIRO to maintain its expertise over a broad range of disciplines. There are opportunities for new products and processes in the mineral processing, petroleum extraction, food processing and consumer chemical industries. This includes new bioremediation products and processes for the clean up of chemical pesticide residues in the environment, in industrial effluents and in commodity processing.

There are significant opportunities to expand the area by better integration with the cleaner production and plasma waste destruction projects. There is also a need to develop high performance specialty adhesives for wood-based composites and to produce environmentally friendly, recyclable preservative systems.

Chemical processing, cleaner production and disposal

Our pilot plant facility will continue to provide tailor made services in chemical processing to the chemical industry—particularly to demonstrate that new, more efficient and environmentally sound technologies are workable at pilot plant scale. Our research also aims to produce plants or instruments which can be used as part of a chemical process.

Plascon and microwave reactors are mature, generic cleaner production and waste disposal technologies which can be applied in the specialty chemicals industry. There are a number of promising related technologies at an early stage of research. Local power utilities, overseas or local specialty chemical companies may be approached in developing applications.

It is the nature of research in this sector that the intellectual property generated can be protected, either through the international patent system or by maintaining technology as secret know-how. CSIRO has well-developed business systems with the capacity to establish intellectual property protection for inventions and to prepare and negotiate formal agreements governing relationships with collaborators.

Marketing and communication

CSIRO will continue to position itself in the chemicals and plastics sector as a high quality provider of research and development capability. Mechanisms and facilities will be available to enable Australian industry to contact and work with CSIRO on specific problems. However, the expectation is also that by working closely with major companies in the Australian industry, CSIRO can become aligned with the strategic direction of these companies.

Marketing initiatives will vary (in mix, timing, intensity) across projects in this sector.

There will be an emphasis on visits to, and by, targeted companies. Other mechanisms used will be market research, site tours, consulting, conference presentations, press releases, advertisements, editorial supervision, advertorial articles for trade magazines, publicity events, exhibitions.

The nature of the marketing of a specific technology is determined by its maturity. If an innovation is derived in-house, then a marketing strategy will be developed as an integral part of a business plan. This plan could include presentations to targeted potential receptor companies by senior project and program staff in conjunction with business staff. Once an agreement is in place, it is usually the client who will determine and control marketing and communication initiatives.

Development of CSIRO's R&D capacity

There will need to be changes made in the skills base due to the refocus. Skills required can be met internally from within or across divisions. There will be a need to call on skills and resources from divisions in other alliances. For example, skills from Manufacturing Science and Technology, and Mathematical and Information Sciences may be used to establish high throughput synthesis and screening facilities. Better integration of science base (polymers and composites) with the organisation's engineering (products/applications/plasmas) base will call on skills and resources from other parts of CSIRO. Collaboration with industry partners will fulfil specific skill needs which are not available in CSIRO.

There will also be changes to facilities due to the refocus. Chemicals and plastics research is traditionally equipment-intensive and biotechnology research has become so over the last five years. CSIRO will need to make ongoing investment in analytical and process equipment. The target will be to invest $2.3 million a year on equipment. The intention is to maximise use of

equipment by making it available to all divisions in relevant sectors and by jointly acquiring and operating very expensive equipment with universities and industry. The recent planning process has highlighted the opportunity to establish a high throughput screening platform with those parts of CSIRO serving the pharmaceuticals sector.

The refocus will also mean changes to the balance of R&D. The science base will be enhanced by changes within project areas. The overall balance between basic and tactical will be maintained in most areas. In areas such as those funded by the Rural Industry R&D Corporations, more funding is expected for basic strategic research.

A number of specific scientific/technological/engineering advances and recommendations for investment in equipment and skills have been identified in the Component Research Plans.

Performance and evaluation measures

A substantial proportion of component projects are covered by existing contractual obligations. Milestones and deliverables have been set and agreed upon. Success of the sector's efforts will be determined by its clients on the basis of these outcomes.

Overall performance of the sector's ability to remain highly innovative and to preserve CSIRO's scientific reputation without sacrificing market focus can be measured a number of ways e.g. customer satisfaction surveys, the number of patents, the number of papers published, the number of new products and processes successfully implemented, invitations to lecture, international recognition of staff, repeat business, favourable press coverage, the number and quality of projects, royalty flows, the ability to meet external funding targets, recognition within CSIRO, amongst peers etc. These will be monitored and assessed periodically.

Sector Coordinator

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Divisional and other participation

Building Construction and Engineering, Food Science and Technology, Telecommunications and Industrial Physics, Molecular Science, Manufacturing Science and Technology, Plant Industry, Forestry and Forest Products, Entomology. CRCs: Molecular Science and Technology, Water Quality and Treatment, Aerospace Structures, Polymer Blends, International Food Manufacture and Packaging Science, Industrial Plant Biopolymers, Tropical Pest Management. Universities: Monash, ANU, Queensland, Swinburne, Melbourne, Swedish and Chinese universities. IR&D Board, R&D corporations (Sugar, Dairy, Cotton, Grains), DIST, AGAL, Department of Conservation and Natural Resources, Australian Forestry Council, NSW Department of Agriculture.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	14.9	15.7	16.7
External funding	11.3	12.3	13.8
TOTAL	**26.2**	**28.0**	**30.5**
External/total ratio	43%	44%	45%

Integrated Manufactured Products

The Sector Advisory Committee forwarded its comments on the Integrated Manufactured Products Sector Plan for 1997/2000 to CSIRO on 13 December 1996. The specific findings outlined in that communication remain valid and I summarise them as follows:

- **Diversity:** The Sector is intrinsically very diverse. Caution must therefore be exercised to avoid too narrow a research focus. This can be achieved by projects which can be categorised as generic to the Sector.
- **Uniqueness:** CSIRO coverage of the Sector has unique characteristics which must be preserved in any process of prioritisation of research activity.
- **External Earnings:** The external earnings targets set for the Sector are a challenge. The Committee queries whether industry in-kind input and commercial equity in research products are properly accounted for in the assessment of external earnings.
- **Generic Technologies:** In assessing coverage of generic technologies, account should be taken of activities which are generic across Sectors as well as generic across industries within the Sector.

With these considerations in mind the Committee considered, albeit with limited insight given that this was its first input to the review process, that the Sector Plan for 1997/2000 directions are appropriate.

Subsequent to the above review, the Committee has commenced a series of inspections and presentations on the work of the Sector. This has confirmed our initial view that an industry scoping exercise or demand study would be most helpful in assessing the issues outlined above. This will provide us with a much sounder basis to comment upon balance between; demand and supply driven research; generic and applications specific research; and, basic, strategic and applied research. Drawing upon the insights of CSIRO Staff, we believe that the Committee will be able to contribute significant input to a scoping exercise and be in a much better position to provide informed input into the setting of Sector planning priorities in the next review.

Yours sincerely,

Dr D. G. Williams
Chair, Integrated Manufactured Products Sector Advisory Committee

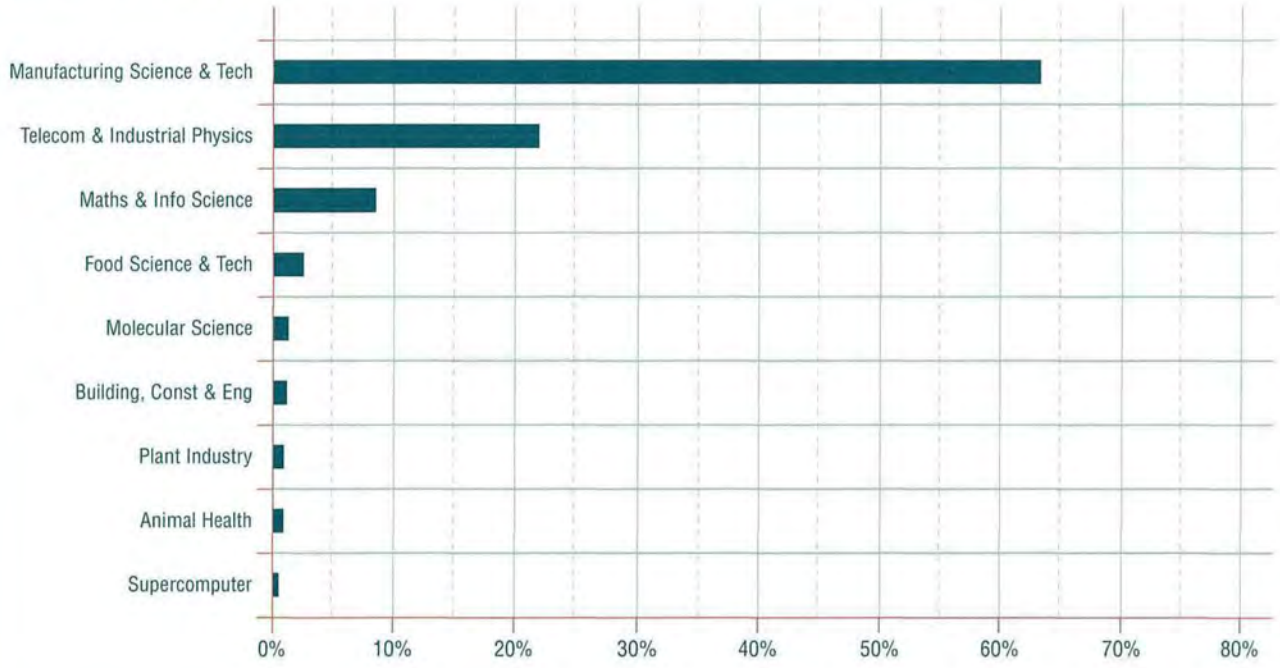
Integrated Manufacturing Products Sector Advisory Committee:

Don Williams (Chair), Company Director; *Mike Holthuyzen*, Dept of Industry, Science & Tourism; *Peter Coates*, Ceramic Fuel Cells Ltd; *Patricia Crook*, Dynek Pty Ltd; *Frank Cunningham*, BHP Co Ltd; *Keith Daniel*, AMBRI Pty Ltd; *Vince Evans*, Federation of Automotive Products Manufacturers; *Roger James*, Business Victoria; *Ross McNeil*, ANI Engineering Division; *Antony Simpson*, Company Director; *Robert Trenberth*, Ernst & Young; *Katherine Woodthorpe*, IT Services

Integrated Manufactured Products

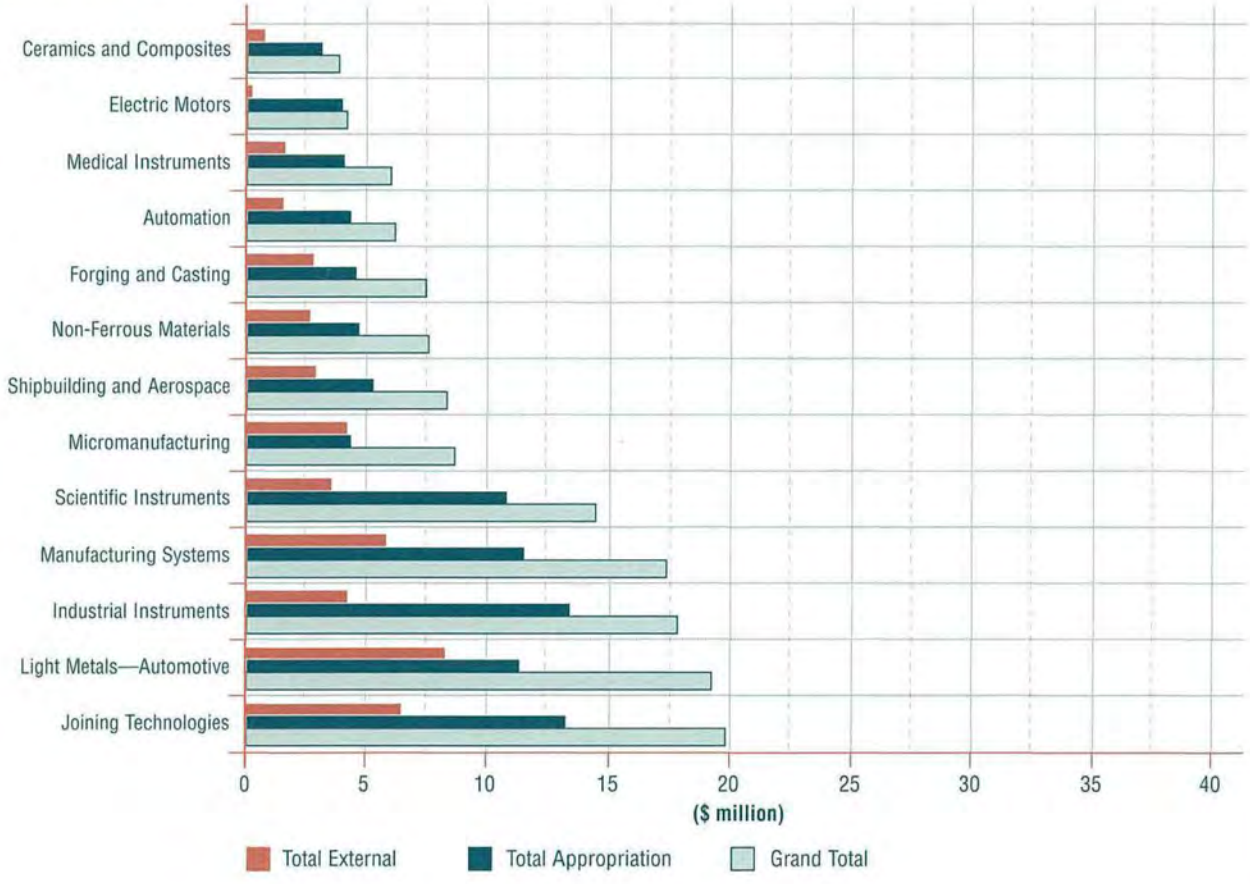
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $140.40 million)



Triennial Investment by Component

(Total Sector Investment $140.40 million)



Integrated Manufactured Products

Mission

To carry out world-class R&D for the benefit of Australia's manufacturing industries, and to ensure the timely transfer of the results of the work to facilitate wealth creation by those industries for the country's economy.

Overview

The Integrated Manufactured Products (IMP) Sector covers predominantly metal-based manufacturing, mainly related to elaborately transformed products. It includes a range of high value-added production, such as instrumentation and other sophisticated machinery and equipment, as well as intermediate goods used or incorporated in other industrial output. Under the ABS classification it draws together the categories of transport equipment, machinery and equipment, fabricated metal products and non-metallic mineral products. It thus comprises about one-half of Australia's total activity in manufacturing. The description of the sector also covers manufacturing processes and associated engineering, management and business improvement issues which are generic to all of these product categories.

Major issues

The major issues to be addressed by CSIRO are predicated upon the rapidly changing environment in which manufacturing industry now operates. This is producing drivers towards:

- more cost efficiency in existing manufacturing processes, and new processes oriented towards a 'make-to-order' philosophy
- greatly improved process control and significantly more automation
- new, differentiated products, often to fill niche markets
- tools for facilitating globally-distributed manufacturing.

Potential value to Australia

The potential value to Australia of addressing these issues is the maintenance of a viable manufacturing sector. This sector continues to employ approximately 14% of the workforce and contributes more than $10 billion to the country's annual export income. Without continuing technological development, the manufacturing sector will irreversibly decline. Other countries will then take over Australia's niches in world markets and Australia's contribution to its domestic consumption of manufactured goods.

For CSIRO, addressing these issues will enable the organisation to:

- provide appropriate R&D support to manufacturing industries
- facilitate the adoption of new technologies by Australian companies
- maintain sufficient scientific and technological awareness to assist local firms in the identification and uptake of the latest developments.

Overall strategies

The overall strategies and approaches will build upon CSIRO's existing successful thrusts, which combine:

- a proactive market-oriented process to identify R&D opportunities based upon dialogue with companies to determine their real needs
- an awareness-raising process to alert companies to the ability of scientific and technological developments to enhance their competitive position.

The divisions involved in carrying out R&D for the IMP Sector have employed a range of external consultation mechanisms to arrive at the present position. The Sector Advisory Committee is the principal source of advice in determining broad industry needs and research priorities. The strong links which both divisions and individuals have with their client bases have also been used to obtain relevant information. These links include key industry collaborators, industry associations and CRC partners.

Major objectives and key potential outcomes

CSIRO's objectives for the sector are to complement the extensive experimental development work, carried out by companies themselves, with longer-term R&D designed to support industry's development needs. At the same time, however, there will be a significant focus on the very important close-to-market, incremental advances demanded by industry, particularly small and medium businesses (SMEs).

Manufacturing processes

The outcomes of R&D in this area will be modifications to existing processes leading to reduced costs, improved quality and greater consistency, and processes configured to work with new engineering materials. At the same time attention will be devoted to 'tailoring' manufacturing operations to accommodate much smaller production runs.

Automated inspection and process control

Outcomes will include better means of inspecting products as they are manufactured (rather than at the end of a production line), and technologies to control the production process based upon the measurement of key operating parameters.

New product development

The primary outcomes will be new forms of scientific and industrial equipment and instrumentation, often originating from the requirements of leading-edge end users within Australia and driven by the necessity to maintain international competitiveness.

Globally-distributed manufacturing

The key potential outcomes will be tools and methodologies which will permit the effective and efficient operation of integrated 'virtual' enterprises, consisting of companies located around the world.

Customers, technology transfer and commercialisation

The anticipated clients and users of the research results cover a very wide range of companies, from large multi-domestic firms manufacturing for both the local and export markets in Australia, to very small start-up companies bringing completely new products to the marketplace. The clients may be conveniently categorised on the basis of the components which make up the total sector plan:

Light metal automotive components

Clients in this area include the four automotive assemblers operating in Australia, major automotive component manufacturers, primary metal producers and industry associations involved in metal casting.

Materials technology for transportation systems

Customers include several aluminium-hull shipbuilding companies, aluminium metal producers and suppliers, aircraft manufacturers and component suppliers, and manufacturers in both rail and general heavy engineering. It is anticipated that some rail authorities will also become clients.

Industrial instruments

The customers of the research results include manufacturers and users of new devices for sensing and measurement in physical processes.

Medical instruments

The clients are two SMEs involved in bringing new biosensors to the marketplace.

Scientific instruments

The customers are small firms from the research, scientific instrument and environment management industries which require new products to meet their commercial objectives.

High performance small electric motors

The clients of this work are manufacturers and users of high performance electric motors, including domestic appliance manufacturers and firms involved in renewable energy device development.

Processing technology for general engineering products

Clients in this category include most of the forging companies operating in Australia, their industry association, and a small number of SMEs associated with the ferrous foundry industry.

Net shape materials processing technology

The customers include companies involved in non-ferrous casting processes, their suppliers of basic raw materials, and high technology firms requiring new materials for their products.

Fabrication technologies for high-productivity manufacturing

Clients include companies involved in the supply of consumables and equipment to manufacturers, metal fabrication companies, and leading-edge end users who are demanding higher quality products at reduced cost.

Enabling materials for advanced manufacturing

Customers in this area are companies which supply the ingredients for advanced engineering materials, and firms whose operations require access to such materials.

Advanced automation systems

Since automation is an enabling technology broadly applicable to virtually all industrial sectors, the clients for this work will be a wide variety of companies concerned with automating and controlling their manufacturing processes.

Intelligent manufacturing and business systems

This generic R&D is potentially applicable to all manufacturing enterprises, ranging from large multinationals supplying major process plant to Australian customers through to SMEs addressing world-wide markets from within Australia. Systems integrators will also be direct clients for the software tools developed.

Micromanufacturing

The users of the research will be organisations which require advanced security systems in their products, and

companies capable of realising the commercial potential of novel micromanufacturing techniques.

The transfer of technology to industry will be facilitated by the research collaboration process. Where appropriate, technical personnel employed by the industrial collaborator(s) will form part of the research project team. Through their exposure to the work as it is being undertaken, these people will be well placed to lead the translation of the technology to the industrial environment at the conclusion of the R&D program. Two-way secondments of staff between CSIRO and industry will also be employed as an element of this process.

In the case of commercial-in-confidence projects, technical reports and presentations to research partners will supplement regular project team briefings. For other research, the usual scientific communication media of peer-reviewed journal papers and conference presentations will be utilised.

The strategy for the commercialisation of research outcomes will be considered at the time of project proposal formulation. Where an industrial collaborator is involved from the outset, the commercialisation strategy will be determined in close consultation with the collaborator. The roles and expectations of each party will be clarified up-front, and the resources likely to be required for successful commercialisation will be clearly identified.

For projects which arise from within CSIRO and for which it is not appropriate to secure an industrial collaborator in the initial stages, regular scientific progress reviews will reveal when an industrial partner or licensee should be sought. In these circumstances, an internal commercialisation strategy will be developed to underpin the marketing of the research activity to a potential commercial partner.

Intellectual property (IP) will be managed in a manner that complies with CSIRO policy. Since scientific research is CSIRO's core business, it will be essential that the organisation retain ownership of its IP. Commercial arrangements will recognise, however, that it is often necessary for an industrial collaborator to have a degree of exclusivity in the market in which it operates. An objective will be to accommodate such commercial realities whilst retaining actual IP ownership by CSIRO, so that the organisation can exploit its core technology without restriction in areas which fall outside the collaborator's field of interest. Where an industrial collaborator wishes to secure ownership of IP for commercial reasons, the pricing of the research will be structured accordingly.

Marketing and communication

A coordinated sector marketing strategy will be developed which uses the resources of the participating divisions. The strategy will employ a process which:

- identifies industry trends and needs
- identifies R&D opportunities arising from the trends/needs analysis
- compiles a statement of the capabilities of the organisation to address these opportunities
- promotes the organisation's capabilities to deliver complete solutions to targeted customers via a structured communications approach
- identifies specific R&D projects in consultation with potential customers, and submits research proposals to those customers
- interacts with the relevant divisions' business units to ensure that contractual issues are addressed in a timely manner
- monitors the delivery of service to the client against agreed milestones
- reviews client satisfaction with progress and outcomes
- utilises client feedback to continuously improve the performance of the organisation and to seek new opportunities.

Specialist communication staff within each division will work very closely with technical and business personnel involved in marketing to coordinate all promotional activities.

Development of CSIRO's R&D capacity

The scientific, engineering and technology advances being addressed draw upon a range of disciplines. The principal activities include development of :

- mathematical modelling techniques for the simulation of manufacturing processes
- knowledge about the influences of manufacturing process parameters on product quality
- new or improved materials for arduous manufacturing process and product service applications
- process technology for forming, fabricating and assembling manufactures
- new generation sensing and detection devices for use in parameter measurement and/or the control of processes
- new tools for designing high-integrity and/or novel manufactured products

- new tools to assist in planning, design and decision-making in manufacturing enterprises
- new products based upon micromanufacturing technologies.

Scientific and engineering opportunities offer two broad categories of new initiatives for appropriation fund investment:

1. In the areas specific to products and processes, greater emphasis is planned in light alloy technology. This is in terms of both the development of the materials and their processing technologies, to respond to the very strong interest from the automotive industry in reducing vehicle weight. The activity will build upon the desire of the upstream producer of magnesium metal to seek heavy involvement in downstream processing in Australia, in conjunction with major automobile manufacturers. The skill base will be enhanced through greater effort being devoted to process modelling, rapid prototyping and studies of microstructure and mechanical properties in magnesium alloy systems.
2. In the generic area, increased resources will be devoted to R&D into the automation and control of manufacturing processes. The driving forces are the requirements of manufacturers to raise productivity in order to achieve greater competitiveness, and to remove the product variability associated with human operators. The scientific and engineering challenges lie in developing real-time inspection and control systems and in integrating these into total system packages. The R&D tasks will require a substantially enhanced skill base which crosses the boundaries associated with the traditional engineering disciplines.

Performance and evaluation measures

External measures

- benefit/cost ratio for completed projects
- level of customer satisfaction based upon successful completion of contracts
- extent of adoption by clients of practices, processes and devices developed by CSIRO
- extent of repeat business
- number of patents arising from externally-supported R&D.

Internal measures

- extent to which projects deliver agreed milestones on time and within budget
- external earnings as a proportion of the sector budget
- extent of shift in resources to agreed priority activities
- number of refereed scientific publications and technical reports.

Sector coordinator

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Divisional and other participation

Manufacturing Science and Technology (171.8 EFT), Telecommunications and Industrial Physics (66.6 EFT), Mathematical and Information Sciences (26.6 EFT), Food Science and Technology (7.1 EFT), Molecular Science (3.1 EFT), Animal Health (1.7 EFT), Plant Industry (2.2 EFT), Building, Construction and Engineering (2.2 EFT). CRCs: Alloy and Solidification Technology, Intelligent Manufacturing Systems and Technologies, Materials Welding and Joining, Molecular Engineering and Technology, Renewable Energy.

FINANCIAL SUMMARY

	($ million)		
	1997–98	**1998–99**	**1999–2000**
Appropriation funds	31.0	30.6	31.9
External funding	14.0	15.5	17.4
TOTAL	**45.0**	**46.1**	**49.3**
External/total ratio	32%	34%	36%

Pharmaceuticals and Human Health

Sector Foreword

Herewith I have pleasure in providing for consideration the Strategic Research Plan for this Sector for 1997–98 to 1999–2000.

Our Committee is fully supportive of the Plan as requested; its narrow focus provides enhanced probability of success in the global industry of pharmaceutical development with great opportunities to increase the general health and well-being of Australians.

The Sector Research Plan combines traditional scientific approaches to pharmaceutical drug discovery and innovative directions. There are clearly forward commitments within the portfolio, reflecting the Sector's present activities, and at the same time clear opportunities for innovation and capture.

The Committee is encouraged by the high standard of facilities available, but recognises the need for critical investment in infrastructure and equipment. These will be necessary to move forward beyond this current triennium.

Importantly, evaluations of technologies within CSIRO and those necessary to take this industry sector forward, and capture the rewards, should be undertaken; strategic alliances should be investigated where appropriate.

The relationship between CSIRO and the NH&MRC as providers of opportunities to industry, general health advice and critical advice to government is under review. Our Committee welcomes this capacity and considered focus of the two organisations, and is encouraged by their receptive attitudes.

On behalf of the Sector Advisory Committee, I commend the Sector Research Plan to your Board and look forward to the opportunity to play a role in the development of this concept.

Yours sincerely

Professor John Funder
Chair, Pharmaceuticals and Human Health Sector Advisory Committee

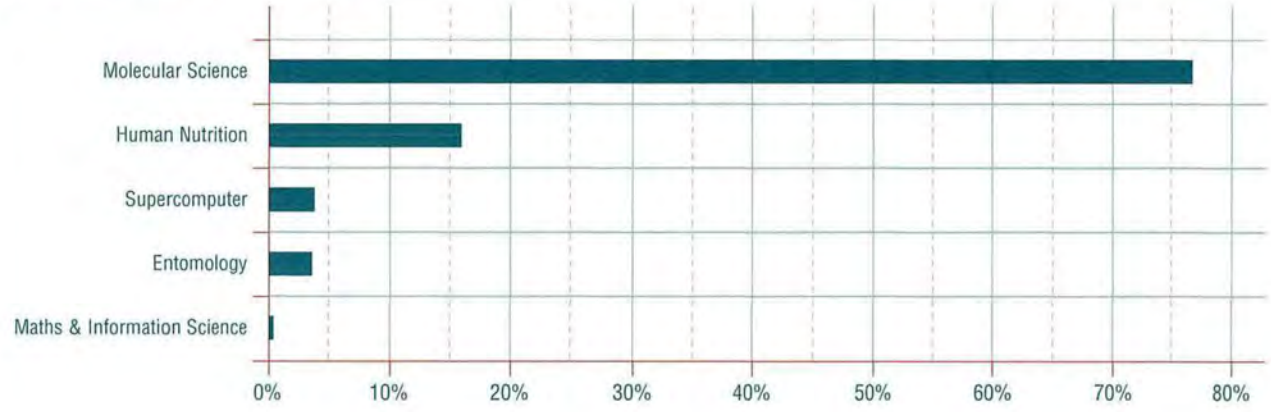
Pharmaceutical & Human Health Sector Advisory Committee:

John Funder (Chair), Baker Medical Research Institute; *Dallas Ariotti*, Health Economist; *Patricia Kelly*, Dept of Industry, Science & Tourism; *Pat Clear*, Australian Pharmaceutical Manufacturers Assoc Inc; *Bill Coote*, Australian Medical Association Ltd; *Graham Thurston*, Australian Diagnostic Manufacturers Association; *Graham Mitchell*, Foursight Associates Pty Limited

Pharmaceuticals and Human Health

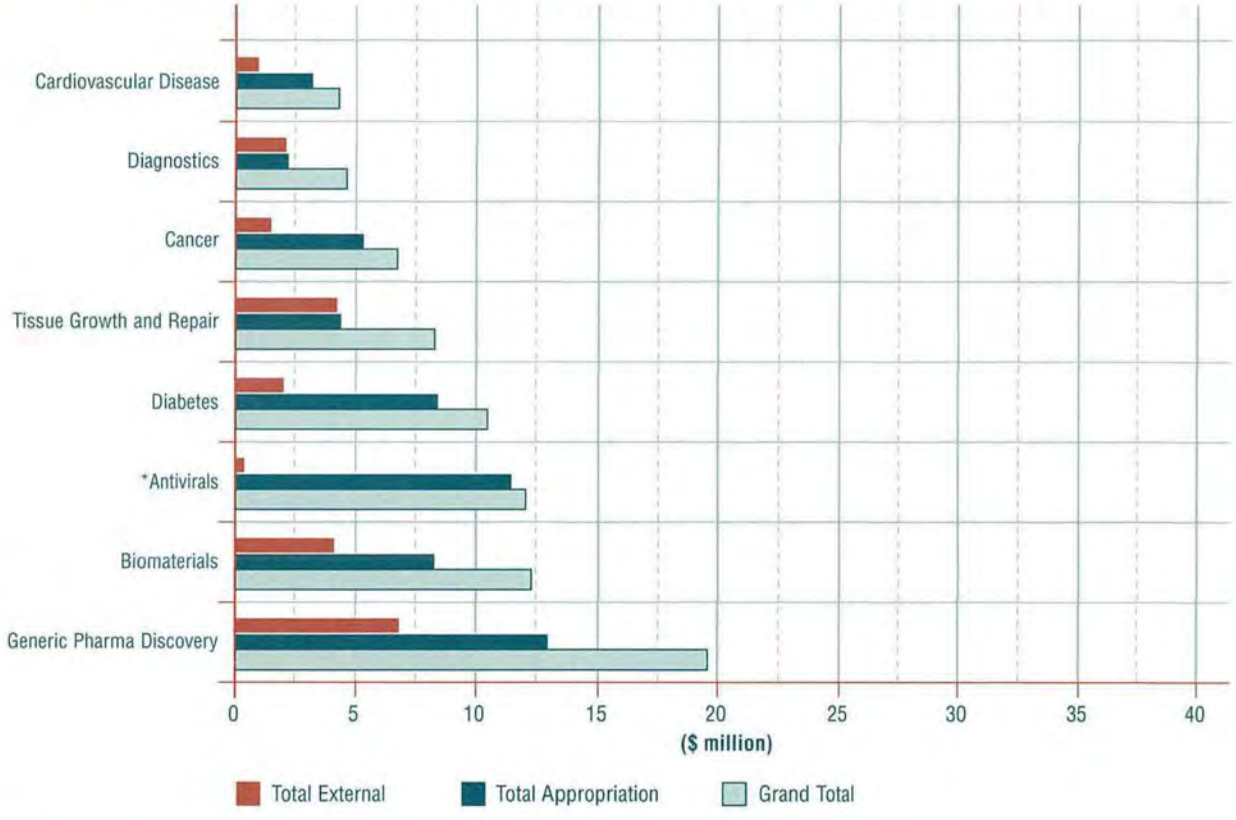
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $82.51 million)



Triennial Investment by Component

(Total Sector Investment $82.51 million, including $3.2 million for supercomputing not shown in the Component costings below)



* Includes CSIRO's contribution to the Biomolecular Research Institute (BRI) but excludes the external income of BRI.

Pharmaceuticals and Human Health

Mission

The sector mission is 'Better medicines for common illnesses'; in this context, 'medicines' means therapeutics, prophylactics and other treatments, including 'nutriceuticals' and preventative strategies.

Overview

Major Issues

At the first Australian Government-CSIRO workshop, the stated government objectives included 'providing health care at a reasonable cost', 'need for growth in the pharmaceutical and medical industries', 'bridging the gap between the National Health and Medical Research Council and applications'.

The research effort is set in the context of meeting these government objectives.

Potential value

Providing health care at reasonable cost is a key national priority. There is scope to contribute to welfare and still contain growth of $36 billion to national health budgets through effective health-related research. Note that benefits may be 'avoided health costs' and benefits associated with increased quality and length of life are additional to wealth creation by local industry.

Public health research can provide significant benefits through greater emphasis on preventative strategies and R&D concerning lifestyle and nutritionally related diseases (e.g. cardiovascular disease), ageing and degenerative diseases, and more effective diagnostic techniques and health care delivery systems.

Research can benefit the economy, through contribution to turnover and growth of the local pharmaceutical industry, as well as a reduction in health treatment costs and improved well-being.

The recent publication, *An Economic Evaluation of Three CSIRO Manufacturing Research Projects*, estimates a benefit-cost ratio of 13.7 (mid range) for the anti-influenza drug which originated in CSIRO and which is now in advanced clinical testing. The net present value (NPV) of this project, $834 million (mid-range), excludes future as yet unknown benefits of manufacturing activities.

The local industry had a turnover of $3.7 billion, with exports of $0.7 billion and imports of $1.4 billion in 1993–94. The Bureau of Industry Economics projects average annual sales growth for Australia's pharmaceutical firms of 7% to the year 2005–06; exports are expected to grow at 13% with employment projected to more than double to 29 000 by 2005–06.

The level and effectiveness of R&D is critical to industry performance. The international industry averages an R&D/turnover ratio of 14%. The substantial increase in Australian R&D effort has now brought its R&D ratio up to 7% of turnover. Stable policy by government is critical to industry investment, which is traditionally long-term.

The gap between basic scientific discoveries and their commercialisation is small in the drug industry. Industry recognises this by its investment in research, often at an early stage; however, the value of the research results increases dramatically as they enter further development. Licenses to new chemical entities can bring a return to the researcher as high as 5–10%, in markets worth in excess of $1 billion a year.

Strategies and consultation

One half of the research portfolio is focused on therapies for common illnesses where there is an unmet medical need. The remainder is split between generic approaches to drug discovery, diagnostics and biomaterials, where the benefits of research are envisaged to be substantially in the pharmaceutical and devices industries, with some direct flow-on benefits to human health.

The plan does not embody a major shift in resources between therapeutic areas when compared to the stocktake of June 1996. In the cardiovascular, cancer and diabetes components, the programs have the potential to become significantly stronger as a result of new links between Divisions.

A new component, 'Generic Pharma Discovery', seeks to develop innovative generic technologies for drug discovery, while integrating current generic technologies into an effective combined approach under the aegis of a corporate CSIRO Fellow.

This plan has been endorsed by the Sector Advisory Committee and has received inputs from various industry associations and contacts.

Major objectives and potential outcomes

Antivirals

- characterisation of the 3D structures of target proteins for drug design; major virus targets are HBV, HCV, RSV and HIV
- development of dendrimer technology against specific virus targets.

CSIRO support of the Biomolecular Research Institute is the major part of this component.

Cancer

Prostate cancer

- development of viral vectors for gene therapy; identification and optimisation of prostate-specific gene regulatory elements for expression of therapeutic genes in cancer therapy
- identification of key proteases involved in metastasis
- evaluation in model systems of selectively activatable 'lytic peptides' for prostate cancer treatment.

Intestinal cancer

- establishment of a database for genetic instability rate to reflect dietary status
- identification of micro and macronutrients, including oxidative free radicals, to minimise tumours and optimise gut health.

Cardiovascular disease

- identification of new chemical entities as inhibitors of arrhythmia, angiogenesis or vascular smooth muscle cell proliferation
- identification of antioxidants and dietary factors for prevention of cardiovascular disease
- through clinical nutrition trials, identification of dietary strategies to prevent or alleviate obesity and to reduce cardio-vascular disease.

Diabetes

- determination of molecular events that lead to glucose uptake at the level of
  - — interactions between insulin and its receptor
  - — the cell-signalling pathways responsible for glucose transport
- identification of therapeutic role of lipids and fatty acids in improving cardiovascular and nervous system function in diabetes.

Tissue growth and repair

- improved formulations for wound repair, tested through to animal studies
- novel factors (natural, recombinant or new chemical entities) effective in treating chronic wounds or in controlling fibrosis
- production of partial agonists of IGF
- development of defined media for mammalian cell culture.

Generic Pharma Discovery

- identification of drug targets of commercial or social value
- refinement of the design principles for ribozymes suitable for gene-targeted therapies
- development of new biological assays and insects as natural products for rapid throughput screening
- development of combinatorial approaches using natural and synthetic chemistries for generic discovery of drugs
- discovery of novel immunoglobulin-like immuno-modulators or small molecule mimics of them
- consolidation of tris-coupling technology for drug and gene therapy delivery
- integration of activities into an effective combined approach.

Diagnostics

- new diagnostic reagents and assay formulations, particularly quantitative assays, based on generic technology for the design and/or selection of proteins with high affinity to target haptens and antigens including nucleic acids.

Biomaterials

- new devices for vision correction, including extended-wear contact lenses and corneal onlays and implants
- implantable medical devices, such as small diameter vascular prostheses, based on advanced polymer and surface modification technologies
- biomaterials based on collagen and hybrid collagen-synthetic substances for wound management.

Customers, commercialisation and communication

Commercial strategy is determined by the long-term goal to contribute to the establishment of a research-based pharmaceutical industry in Australia.

The major end user of the research results is the international pharmaceutical industry, possibly through an intermediary based in Australia. The industry places high value on protected intellectual property and little or no value on unprotected or unprotectable discoveries.

On the way to assisting small local companies to a position of strength where they can invest over $200 million at risk to develop new drugs fully, it will be necessary to attract investment from international

companies to help build the local industry. The principal leverage is intellectual property. Attracting commercial parties to projects too early may compromise such an outcome. External earnings are likely to remain less than 30% while exploitable intellectual property is being developed, but can become substantial through research milestone payments and future royalties.

CSIRO's *Health Industry Research Directory* will be maintained and updated annually. Progress in all entries currently outside the sector will be monitored for developments which would suggest formal inclusion in the sector in future.

The achievement of closer and more strategic relationships between the National Health and Medical Research Council (NH&MRC) and CSIRO is a shared objective. Development of such understanding should clarify the roles of each organisation in Australia's health and research systems. Effective coordination with the CSIRO Service Sector will be necessary for unambiguous interactions with the federal Health department and the NH&MRC.

Development of CSIRO's R&D capacity

The sector process is forging new partnerships within CSIRO. Matrix management will be applied to integrate research skills focused on particular therapeutic areas, consistent with the pharmaceutical development industry. This is necessary because drug discovery is a complex task involving many disciplines with scientific and technical uncertainty and high economic risk.

Better understanding of the regulatory arena and of 'good manufacturing practice' and 'good clinical practice' issues is becoming important and will be addressed through interaction with CSIRO's customer base and the national regulatory authorities. The generation of molecularly diverse libraries (for high throughput biological screening) and bioinformatics (linked to structure-based design) will both be central to future drug discovery. Neither of these activities is particularly well-resourced within the sector. Strategic development in these areas will be undertaken within CSIRO and national facilities facing similar technology challenges.

Coordination with other efforts within CSIRO will be essential for maximum return on investment. Exploitation of synergies between biopolymer and synthetic polymer research will produce intellectual capital for new biomaterials. A general run-down in the capital base has occurred, putting items of equipment as a priority.

Performance and evaluation measures

- completed patent filings
- license agreements to industry
- publications
- external income of 28%
- meeting milestones in CRPs and in external agreements
- customer/collaborator satisfaction.

Performance will be measured at the level of the CRP and coordinated centrally in consultation with the SAC. Pending approval, benefit-cost analysis will be undertaken for CSIRO's involvement in one of the first-round CRC's.

Sector coordinator

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Divisional and other participation

Molecular Science, Human Nutrition, Entomology, Mathematical and Information Sciences, Corporate CSIRO Fellow. CRCs: Tissue Growth and Repair, Cellular Growth Factors, Eye Research and Technology, Cardiac Technology, Diagnostic Technology. Biomolecular Research Institute.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	19.2	19.9	20.3
External funding	7.7	8.0	7.4
TOTAL	**26.9**	**27.9**	**27.7**
External/total ratio	30%	30%	27%

Coal and Energy

Sector Foreword

I write in my capacity as the Chair of the Advisory Committee for the CSIRO Coal and Energy Sector.

The Advisory Committee has reviewed the Sector Plan, the Component Research Plans and the issues that will impact on the Sector over the next CSIRO funding triennium.

The Committee compliments CSIRO on the role of the Sector Planning process in strengthening links both within and outside CSIRO.

There was general endorsement by the Committee on the distribution of resources across the Sector. Further information will help to more effectively assess future resource distributions, particularly more detailed benefit/cost analyses of the activities.

We recommend raising the priority of the Sector within CSIRO. The relatively low position on the CSIRO attractiveness/feasibility screen is not compatible with a Sector that employs leading edge mining and processing technologies which are acknowledged as providing Australia with a competitive edge. Nor does it reflect the crucial influence the Sector can bring to bear to environmental issues, particularly greenhouse gas emissions and control. Indeed there was support for changing the name of the Sector to Clean Energy Technology or preferably, the Energy Sector.

There were mixed opinions regarding the Sector's 40% external earnings target, however the 40% should be viewed as a performance indicator and be reviewed annually.

A full meeting of the Sector Advisory Committee once a year is adequate, but the Sector Coordinator should issue half-yearly position papers concentrating on any issues where the intent has changed. Individual contacts throughout the year between the Sector Coordinator and Sector Advisory Committee members are expected along with visits of Committee Members to CSIRO sites.

Yours faithfully

J.C. Hannah
Chair, Coal and Energy Sector Advisory Committee

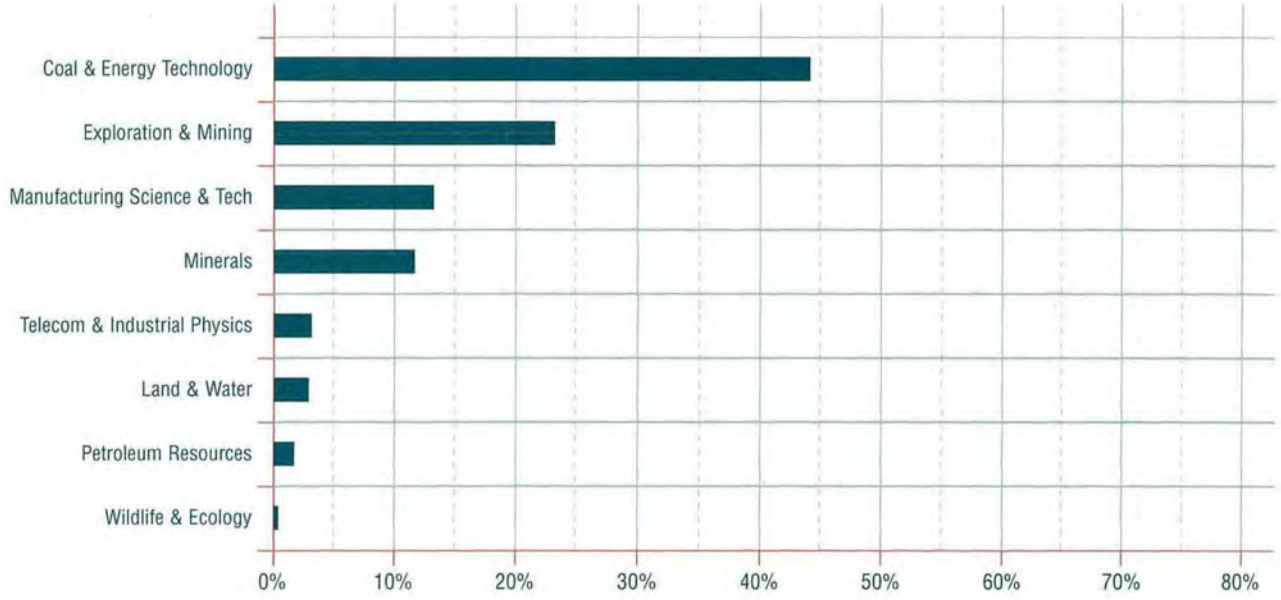
Coal and Energy Sector Advisory Committee:

John Hannah (Chair), BHP Coal Ltd; *Margaret Beardow*, Electricity Supply Association of Australia; *Noshir Bharucha*, Dept of Primary Industries & Energy; *Robyn Bryant*, Dept of Primary Industries & Energy; *George Edwards*, Consultant; *Ross Graham*, Australia Coal Research Ltd; *Don Nicklin*, Consultant; *Keith Orchison*, Electricity Supply Association of Australia; *Terry O'Reilly*, Coal & Allied Ltd; *Bruce Robertson*, Shell Coal Australia Ltd; *Jane Robertson*, NSW Minerals Council; *John Sligar*, Consultant; *Jim Smitham*, BHP Research; *George Webb*, Australian Gas Association; *John Zillman*, Bureau of Meteorology

Coal and Energy

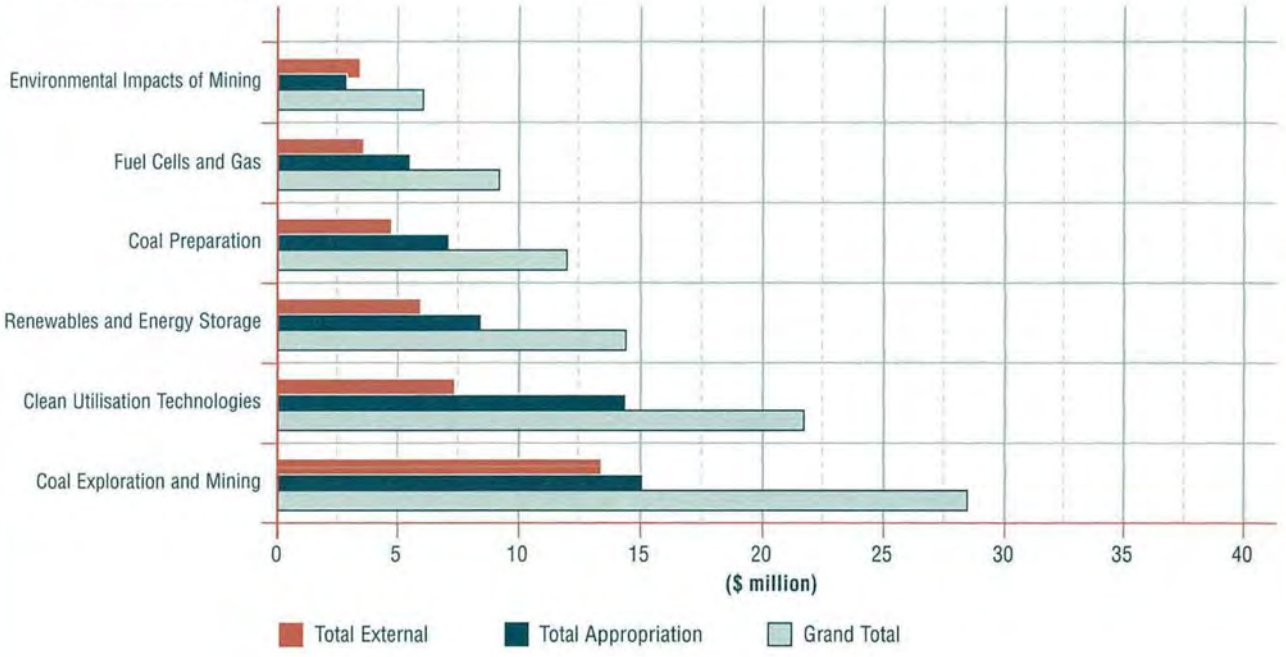
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $92.06 million)



Triennial Investment by Component

(Total Sector Investment $92.06 million)



Coal and Energy

Mission

To deliver R&D outputs that improve efficiency, sustainability, and environmental acceptability in the supply and use of energy resources.

Overview

Australia needs to build the most efficient industry it can afford, using world's best practices. The sector theme is 'sustainable technologies linking energy, economics and environment'. The vision is for CSIRO to be the world-leading centre for energy R&D.

Major issues

The major issues to be addressed by CSIRO include:

- international competitiveness in the cost and quality of coal production, encompassing environmental and safety aspects
- higher efficiencies and better environmental performance (reduced greenhouse gas and other emissions) across fossil energy conversion to electric power and other uses, including clean coal technologies
- lower costs and mainstream market penetration for renewable energies and storage
- expansion of niche technologies, equipment and services especially for export
- leadership in R&D and technological aspects of the National Sustainable Energy Strategy and of international energy collaboration.

Value to Australia

The value to Australia and CSIRO of addressing such issues reflects the fact that energy underpins industrial productivity and living standards worldwide. Australia is an energy leader located in the world's fastest growing region (Asian energy growth is 8% pa.). Coal is the nation's largest export. Energy contributes around $40 billion to GDP. Energy R&D is also closely linked with environmental issues and government policies as well as with business directions. More specifically, the value lies in:

- Maintaining and enhancing the world-leading status of the coal industry, currently over $8 billion a year in exports with strong projected growth. Benefits derive from greater coal recovery, reduced costs, lower penalties or bonuses from better or more consistent quality, access to established and new markets, value-added products and technologies, and also lower production losses due to safety issues. Overall benefits should exceed $1 billion a year.
- Improving competitiveness, flexibility, and export potential within the $12.3 billion electricity supply industry, which is changing rapidly towards (inter alia) private power production and co-generation, competition between fuels, and smaller-scale decentralised power plants.
- Expanding and diversifying gas-based industries, both export and domestic, and establishing value-added, technology-based industries in fuel cells, renewable energies and energy storage. Long-term benefits exceed $1 billion a year in some cases.
- Facilitating a strategic energy mix and greater security in liquid fuels, where the current trend is towards much expanded imports.
- Realising environmental benefits from higher efficiency, emission controls and waste utilisation. For example, clean coal technologies have the potential to reduce CO_2 emissions by 25–60% and Australia has a significant international role in this context.

Overall strategies and approaches include:

- Continuing R&D on unit operations within exploration, mining, preparation, and utilisation of coal, including instrumentation, control and automation; this will range from commercial implementation of established projects to initiation of efforts in other economic leverage areas prospective for technological advances.
- Increased emphasis on holistic (system) approaches linking
  - — deposit delineation, mine design, mining productivity and raw coal quality, coal preparation and clean coal products (pit-to-port optimisation)
  - — fuel quality, power generation efficiency, and environmental impacts.
- Ongoing reorientation towards clean coal utilisation technologies that radically transform efficiency and environmental performance, while also providing R&D to improve operational efficiencies for established power generation processes.
- Parallel thrusts towards a strategic energy mix, both resource and technology based, in non-coal fossil energy, specifically gas production (coal seam methane), gas utilisation and fuel cells.
- Ensuring long-term sustainability and environmental and political acceptability via targeted activities on renewable energies and associated energy storage, with particular reference to large scale capabilities and hence mainstream applications.
- Addressing site-specific environmental impacts on air, water and land, as well as the broader regional and global impacts, in collaboration with the

Environment and Natural Resource Alliance. This approach includes greenhouse gas emissions and their reduction via higher efficiency power generation technologies and other means.

- Collaboration with other sectors in areas of overlap: coal use in metallurgical applications, particularly coke making, gas production, conversion and end use, and energy end use efficiency.
- Providing leadership in R&D and technology requirements for national energy policy and in respect of international energy collaboration.

External consultations

External consultations in formulating this plan have involved direct discussions with:

- Sector Advisory Committee members, both individually and collectively
- specialist consultants, former Divisional Advisory Committee members and key clients. There have also been indirect contributions (via past and ongoing interactions) from numerous sponsors and collaborators across the spectrum of component activities, and international companies, energy agencies, and overseas government organisations.

Major objectives and key potential outcomes

The scope of the sector covers energy resources, supply and use.

Energy resources includes the exploration, mining and recovery and preparation and processing of energy minerals—together with the collection and storage of renewable sources.

Energy supply includes transformation or conversion of these resources into electricity, heat, transport fuels and petrochemical feedstocks, coke for steelmaking or other value-added products.

Energy use is ubiquitous, crossing all sectors of the economy and community activities.

Current CSIRO sectoral arrangements are such that there is overlap with other sectors—Petroleum Resources, Mineral Processing and Metal Production, and Built Environment (Utilities)—leading to less than desirable coverage of some areas. Consequently, a key element of a long-term strategy is to achieve more rational arrangements under an expanded **Energy Sector**.
All aspects of energy also impact on the environment. Currently only site-specific environmental aspects are part of the sector while regional aspects (e.g. acid rain, photochemical smog) and global aspects (e.g. greenhouse gas emissions) are part of CSIRO's general environmental sectors.

The sector will focus on six major components, with more emphasis on a systems approach within and across components, compared to the thirteen subsectors of variable size delineated by the 1995–96 Stocktake. The planned targets in this context are:

Coal mining

- better predictive tools for delineating and evaluating coal deposits
- improved mine planning and production control, including gas from coal, based on sensors and guidance systems together with geotechnical advances
- improved mining technologies and machine reliability and automation
- early detection and control of outbursts and fires, and
- improved rescue vehicles.

Coal preparation

- new and improved unit operations
- integration with instrumentation and process control
- overall flowsheet optimisation and new generation plant design
- recovery from tailings ponds.

Clean utilisation technologies

- matching and optimising Australian coals to new technologies with reduced greenhouse impact
- advances in environmental control for gases and particulates
- niche development of technologies and equipment
- co-firing coal and waste materials.

Fuel cells and gas

- improved techniques for coal seam methane extraction
- initial commercialisation of high efficiency gas to electricity conversion
- strategic partnership with restructured gas industry on R&D needs including cogeneration, conversion and end-use.

Renewable energy and energy storage

- biomass and waste utilisation for greenhouse-neutral energy
- large-scale thermochemical storage

- advanced batteries and capacitors
- wind energy optimisation.

Minesite rehabilitation

- spoil pile landform design
- tailings pond stabilisation
- ecosystem development.

Some clean utilisation technologies for coal, including new cokemaking approaches for steel production, are undertaken in the Mineral Processing and Metal Production Sector but may accord better with the Coal and Energy Sector. Gas R&D will be integrated with Petroleum Sector activity, pending rationalisation. Energy end use efficiency may be undertaken with respect to energy-intensive industries, in conjunction with the Built Environment Sector if resources are available.

In respect of possible new, high-impact initiatives, three possibilities are currently short listed:

- efficient, greenhouse-friendly coal gasification
- mine safety and communications
- cost-effective extraction and utilisation of coal seam methane.

Customers and technology transfer; marketing and communication

The Coal and Energy Sector encompasses a wide range of industry and other stakeholders—23 types were listed under five categories in the Sector Outlook. The major clients and users of the research results are:

- multi-national resource producers such as BHP Coal, Shell International and many small companies, including contract miners
- the energy supply industry, including Pacific Power, United Energy, Western Power, Energy Australia
- industry associations such as ACARP, AMIRA, ILZRO
- government agencies such as SERDF, ERDC, AusIndustry, Worksafe and Insurers
- equipment manufacturers and suppliers in mining, processing, power, and in enabling technologies such as instrumentation and process control.

The sector has a favourable track record in R&D and is globally competitive and internationally active. The restructuring of the utility industries provides long-term opportunities to compensate for the short-term negative impact. R&D and technology transfer is vital for the developing industry areas like renewables and the manufacture of mining and energy equipment. CSIRO also has a major role in the transfer of overseas R&D and the selection, modification and application of imported technologies; there is synergy of Australian coal and energy resources with the products of overseas technology developers and suppliers. International collaboration is important, with IEA, WEC, APEC and so on.

The commercialisation strategy involves potential customers at the earliest possible stage. CSIRO will carry out initial R&D to 'proof of concept' in-house, retaining the intellectual property, then proceed to scale up with increasing industry support. Joint ventures (such as Ceramic Fuel Cells Ltd) will be established where appropriate. Commercial partners are expected to pay patent costs. A policy of full cost recovery for tactical R&D, testing and consultancy, ensures that external funding is maximised, with concomitant reinvestment in new strategic projects.

The marketing strategy includes continuing direct interactions with industry and stakeholders (at different levels of decision-making), and indirect contact through newsletters, trade journal articles, publications, conferences, workshops and seminars etc. This strategy aims to enhance prospects via:

- major field demonstrations of specific technologies and of overall capabilities
- development of pilot R&D facilities located at industry sites
- use of expert consultants on retainers and other incentives. This has been successful in some component areas in increasing industry interaction and external funding, and in broadening scientific, engineering and project management capabilities
- *The Australian Coal Review*, covering the whole coal chain, with articles from many sources across the industry, government and R&D organisations—organised, edited and published through the Division of Coal and Energy Technology
- international companies and agencies with some focus on Japan and USA, thereby aiding participation in globalisation of technology and trade (Australia is also a relatively low-cost R&D source).

The Sector Advisory Committee is expected to play an important and proactive role.

Development of CSIRO'S R&D capacity

Scientific and engineering advances are being sought in response to market needs. These advances and the technological opportunities that have been identified include:

- 3D minescale visualisation
- improved predictive tools
- mining technology and automation
- gas stimulation
- control of outbursts and fires
- advanced coal preparation unit operations and integration
- optimisation of the gasification of Australian coals
- new coke-making processes
- commercial scale fuel cells
- large-scale thermochemical storage of solar energy
- advanced capacitor and battery storage
- wind resource optimisation
- biomass and waste utilisation
- spoil pile and tailings dam rehabilitation.

The concomitant investment in science and engineering disciplines, and development of the skills base, includes maintaining (or, in the cases indicated by * below, extending):

- **Physical sciences:** geology, suspension fluid dynamics, surface and colloid science, catalysis, advanced materials and carbons, combustion/gasification, electrochemistry, trace analysis
- **Engineering sciences:** geotechnics, mining engineering*, separation engineering*, ceramic fabrication, thermochemical processing, safety engineering*
- **Enabling technologies:** instrumentation, sensors, flow imaging, machine vision and robotics*, automation and process control.

There is a special potential for greater integration of the above three categories and, in cross-disciplinary teams, to achieve a systems approach to tackling major issues and problems. CSIRO needs to recruit key staff with industry backgrounds and technological expertise, to complement existing core scientific capabilities in certain areas and to facilitate extensive national and international collaboration.

Performance and evaluation measures

The measures of success for internal management and coordination comprise:

Industry relevance

- external funding and agreements
- participation and collaboration
- commercial implementation
- spinoff ventures
- cost to benefit ratios.

Industry reputation

- delivery on time and on budget
- demonstrations in industry environments
- invited business
- repeat business
- secondments.

Scientific and engineering reputation

- publications, reports, patent
- international visitors and recognition
- invitations and participation on committees
- CRC and university involvement and collaboration.

Skills and facilities

- equipment availability and usage
- pilot and demonstration capabilities
- expertise development and recruitment
- succession planning.

These are monitored by a variety of established processes—internal management systems, industry panels and monitors, client satisfaction surveys for every project, the Sector Advisory Committee, external consultants etc.

The measures for external reporting purposes include:

- absolute and percentage change in appropriation, external and total expenditure for the sector and its components, planned and actual (triennial) expenditure

- external earnings for sector and Divisions (annual)
- divisional contracts successfully completed (via annual customer signoff)
- adoption or commercial implementation on a major outcomes basis (annual)
- number, type and quality of publications (via citation analysis), on an annual or triennial basis
- training—the annual number of postgraduate students supervised or sponsored, in part or in whole.

Sector coordinator

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Divisional and other participation

Coal and Energy Technology (88.2): Exploration and Mining (46.2): Manufacturing Science and Technology (22.1): Minerals (24.8): Telecommunications and Industrial Physics (6.7): Land and Water (6.6): Petroleum Resources (4.4): Wildlife and Ecology (0.5). CRCs: Mining Technology and Equipment; Black Coal Utilisation; Power Generation from Low Rank Coal. There is also participation in international R&D programs, such as IEA, whereby costs are shared and capture of benefits is enhanced.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	17.3	17.9	18.3
External funding	12.6	12.8	13.1
TOTAL	**29.9**	**30.7**	**31.4**
External/total ratio	42%	42%	42%

Mineral Exploration and Mining

The Australian minerals industry is one of the nation's truly world-class performers, being the pre-eminent supplier of bauxite, diamonds, lead and zircon. Internationally, Australia is also a major supplier of zinc, iron ore, uranium, gold, silver and nickel products.

Sustained success for Australian mining companies is dependent on the discovery and exploitation of large, economically significant deposits which have the ability to profoundly influence profit margins and national economic performance through export revenue, employment and tax revenue payments.

The local industry is coming under increasing pressure to maintain its international competitiveness in the face of falling real commodity prices, higher production costs, competing land uses and emerging mining economies overseas. CSIRO has a critical role to play in helping Australian companies maintain their competitiveness in an increasingly global environment through the development of new and improved exploration and extraction technologies and processes.

Overall, I believe that the CSIRO's planned research effort in support of the Mineral Exploration and Mining (MEM) Sector across the 1997/98–1999/2000 triennium is closely aligned with the key issues and priorities identified by the MEM Sector Advisory Committee (SAC).

However, as with any strategic planning process there are a number of matters which require further attention by the Organisation, in collaboration with the SAC, as the Sector planning process evolves over time. These include:

- Clarifying CSIRO's role vis-a-vis other R&D providers, both nationally and internationally, to minimise competition and duplication of effort.
- Ensuring that the benefits flowing from the Organisation's research effort are as widely disseminated as possible throughout the Sector. In other words, CSIRO must be careful not to allow a small number of companies to "capture" the majority of the R&D outcomes to the exclusion of other Sector participants.
- The role of CSIRO in supporting Australian mining companies working overseas.

I commend CSIRO for seeking to forge an even stronger relationship with the Australian minerals industry through the adoption of the Sector Planning Process. In collaboration with my SAC colleagues I look forward to working with John Read and the CSIRO Divisions which contribute to the MEM Sector as the Organisation determines its future research directions.

Yours sincerely,

R. J. Carter
Chair, Mineral Exploration and Mining Sector Advisory Committee

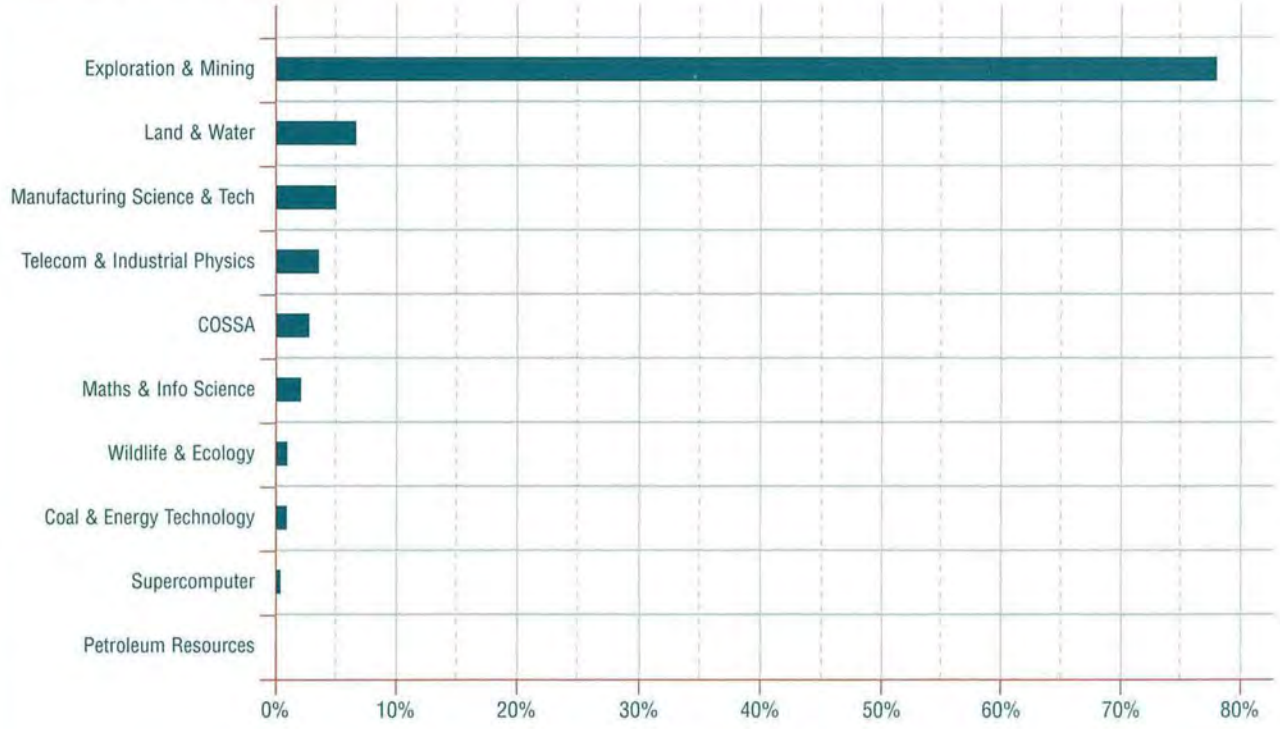
Mineral Exploration & Mining Sector Advisory Committee:

Dick Carter (Chair), BHP Minerals; *Alan Broome*, AUSTMINE-ACIRL; *Dick Davies*, Australian Mineral Industries Research Association; *Ed Eshuys*, Great Central Mines; *Ross Farden*, Consultant; *Rob Rawson*, Dept of Primary Industries & Energy; *Ron Kay*, CRA Ltd; *Robert Rigo*, Edon Gold Mines; *Vivienne Snowden*, Snowden Associates; *Volker Tillman*, Consultant; *Tom Whiting*, BHP Minerals; *Mark Woffenden*, Hamersley Iron Pty Ltd

Mineral Exploration and Mining

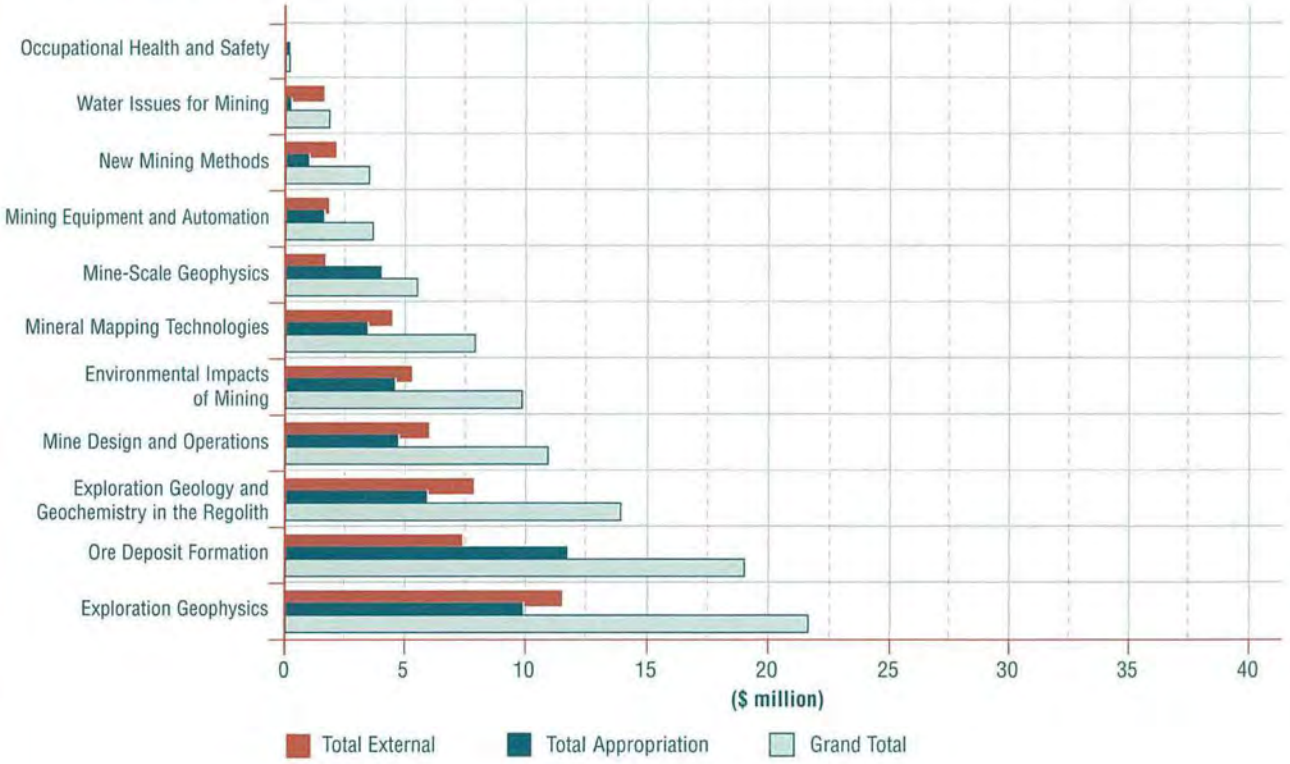
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $98.08 million)



Triennial Investment by Component

(Total Sector Investment $98.08 million)



Mineral Exploration and Mining

Mission

To work with the sector to identify opportunities and deliver solutions through outstanding science and engineering.

Overview

The Mineral Exploration and Mining Sector underpins Australia's world-class minerals industry, encompassing exploration, mining and processing of minerals (including coal and petroleum products) up to the stage where a basic mineral commodity is produced.

The sector is specifically concerned with the exploration for, and mining of, economically viable, naturally occurring, solid, inorganic mineral deposits. Environmental impacts of mining, minesite rehabilitation and occupational health and safety considerations are included within the sector's scope of activities.

Internationally, Australia is one of the world's leading resource nations. It is the world's major supplier of mineral sands (55% of total world production), bauxite (40%), diamonds (40%) and lead (16%). In global terms, Australia is also a major supplier of iron ore, gold, zinc, uranium, silver and nickel products.

The sector accounted for $5.3 billion in turnover and added $3.1 billion value to the economy in 1992–93, the latest year for which complete ANZSIC data is available. Exports of mineral ores and concentrates exceeded $2.3 billion in 1994–95 (up 21% from 1989–90).

Importantly, the sector provides the feedstock for the nation's mineral processing and metal production industries, which contributed a further $15 billion in valuable export income in 1994–95.

As we move into the 21st century, the sector will experience increasing pressure to maintain its international competitiveness in response to:

- falling commodity prices in real terms
- the diminution of many of Australia's more easily accessible deposits, forcing exploration and mining activities into deeper, more difficult environments, with higher operating costs
- increasing community concern over the environmental and social impacts of mining
- the emergence of major mining economies overseas, in which Australian companies are actively participating.

The sector must continually improve the efficiency of existing technologies and processes, and develop new ones, if it is to maintain its current position at the forefront of an increasingly globalised minerals exploration and mining industry. Critical success factors for the sector include:

- a better knowledge and understanding of the processes that lead to the formation of world-class ore deposits, and their associated 'signatures'
- enhanced geophysical and geochemical exploration technologies
- improved mine planning and design
- better mine production control
- improved or new mining processes and equipment
- attention to water quality and supply constraints
- the development of environmentally benign mining processes
- improved strategies for whole-of-mine rehabilitation planning
- enhanced levels of occupational health and safety.

Advances in the areas of mineral exploration, deposit delineation and mining have the potential to significantly improve the profitability of the sector and Australia's overall economic performance. Recent CSIRO achievements include a significant role in:

- the discovery of major contributions to new gold deposits in the Yilgarn region of Western Australia, in particular the Plutonic and Bronzewing deposits which have an estimated value of $4.5 billion
- the forecast increase in Australia's share of the world nickel market from 8 percent to around 24 % over the next five years
- assisting Australian mining companies and both Federal and State Governments through expert reviews and multi-disciplinary research into the development of innovative solutions to minimise the environmental impacts of mining.

Importantly, the community benefits which accrue from the sector's activities extend far beyond the direct income, employment and taxation impacts. Recent studies on the Western Australian mining industry have shown that a $100 million increase in the output of mining generates an additional $100 million in the output of non-mining industries. Moreover, a $100 million rise in wages and benefits paid by mining generates nearly $200 million of wages in non-mining industries, and for each additional 100 people employed by the mining industry, about 300 new jobs are created elsewhere in the State.

CSIRO's research effort across the triennium will be characterised by:

- a stronger emphasis on multi-disciplinary teams drawing on expertise from divisions throughout the organisation

- increased collaboration with other research providers in both the public and private sectors
- closer interaction with service companies and SMEs
- a balanced portfolio of tactical, collaborative and long-term, fundamental research.

Objectives and outcomes

Major objectives

CSIRO's research activities in support of the sector span the full spectrum of metalliferous mining activities, from primary exploration through to minesite rehabilitation. The organisation's activities to the turn of the century reflect the breadth of this research effort, with the major objectives being to:

- provide a conceptual framework to guide the development of predictive exploration strategies for world-class ore deposits
- develop more cost-effective geophysical and geochemical methods and technologies to locate quality ore deposits
- develop integrated technologies for ore body delineation and rock mass characterisation
- enhance minesite productivity by improving existing mining systems and developing new, innovative mining technologies
- develop design criteria and technologies which minimise the impact of mining on the environment
- develop and apply technologies to improve minesite occupational health and safety.

Research outcomes

Research outcomes across this period will include:

- new concepts for the formation of world-class ore bodies, leading to predictive ore genesis models for application in the most predictive terrains
- isotopic analytical techniques applicable to the metallogenic assessment of prospective terrains, ore body detection and exploration through cover
- accelerator-based, micro-analytical techniques for ultratrace element and isotopic analysis of minerals
- cost-effective airborne electromagnetic exploration techniques, to assist in the discovery of ore bodies concealed by the deep regolith
- airborne gravity gradiometry systems of sufficient sensitivity and spatial resolution for use in mineral exploration
- commercially operational capabilities for routine, non-invasive mineral mapping using low-cost, visible and infrared field, airborne and spaceborne spectroscopy
- a framework for the three-dimensional evolution of the Australian landscape by integrating geomorphic, geological and geochemical processes and concepts
- advanced IT systems for data manipulation and visualisation for exploration, ore body delineation and mine design
- monitoring tools and models for the temporal behaviour of rock masses
- production control tools to improve equipment availability and utilisation
- machine control technologies and processes for automated mining systems
- non-explosive rock breakage technologies with particular emphasis on hard rock mining
- improved methods for simulation of groundwater flow and contaminant transport
- design criteria and standards for constructed landforms (e.g. tailings dams)
- monitoring and control technologies to effectively manage minesite hazards.

Customers, technology transfer and commercialisation

The sector's customer base comprises:

- Federal and State Governments and their respective agencies
- exploration and mining companies, from major multinational mining houses with significant in-house R&D capabilities through to 'junior' explorers
- mining supply companies (generally SMEs), and mining contractors and consultants
- peak industry groups, such as AMIRA, the Minerals Council of Australia and State chambers of mines.

CSIRO's research activities result in both knowledge-based and technology-based deliverables. Knowledge-based deliverables (KBDs) include advances in scientific principles and incremental improvements in scientific concepts and paradigms. Technology-based deliverables (TBDs), on the other hand, include developments and products such as scientific equipment, software and processes. Technology transfer of KBDs occurs predominantly via reports, publications, workshops and education programs. Technology transfer and commercialisation of TBDs occurs via:

- collaboration with industry partners and subsequent licensing of technology to them
- co-development with industry partners, or licensing of technology to single parties, for specific one-on-one applications

- funding and development of large-scale commercial projects
- the CRC program and AMIRA, which represent important vehicles for the transfer of both KBDs and TBDs to the sector.

A key element of CSIRO's future research support activities will be the early identification of potential commercialisation partners, in order to enhance the transfer of R&D outcomes to the sector.

Marketing and communication

Effective marketing of CSIRO's capabilities and achievements is crucial to the Organisation's longer term future, both in terms of bi-partisan political support and attracting essential private sector funding to maintain the current research effort.

The primary marketing objective over the three years of the triennium will be a more client-focused approach to R&D activities. A prerequisite for success in this area will be a better understanding of customer needs and aspirations, through liaison with the Sector Advisory Committee and other customer and stakeholder representatives. This input, together with complementary and comprehensive market analysis and assessment, will provide the basis for rigorous market planning and the identification of new opportunities.

Key elements of the organisation's marketing and communication activities in support of the sector will be:

- the development of a comprehensive external communication program aimed at promoting CSIRO's capabilities and achievements
- the implementation of a customer feedback program.

The external communication program will encompass three distinct areas:

- government liaison
- industry and customer relationships
- marketing communication and public relations.

The customer feedback program will have, as its key elements:

- the continuation of customer satisfaction surveys
- enhanced formal review processes for all projects upon completion
- the introduction of regular customer focus groups.

Both the external communication and customer feedback programs will be developed through a consultative process involving marketing and communication personnel from the various CSIRO divisions contributing to the sector. Overall responsibility for coordinating this process will rest with the CSIRO Division of Exploration and Mining and the sector coordinator.

Development of CSIRO's R&D capacity

CSIRO's core capabilities in support of the sector's activities encompass a range of disciplines and competencies, including:

- structural geology
- petrology
- geochemistry
- airborne and borehole geophysics
- remote sensing
- computer modelling
- mine planning
- engineering
- geomechanics
- environmental science
- engineering.

The organisation's competitive advantage lies in its ability to bring these skills together in multidisciplinary teams capable of addressing issues of national importance in a timely and effective manner.

CSIRO has identified the following high-impact, core science areas which will be the major focus of its research efforts over the next triennium:

Processes governing mineralisation, alteration and landscape evolution

Scientific and technological advances being sought in this area include:

- fully coupled thermal, mechanical, fluid and chemical processes
- fluid-rock interaction, weathering and diagenesis
- mantle processes and crust-mantle interactions
- lava emplacement mechanisms and basin evolution.

Advanced instrumentation systems for geophysical and geochemical exploration, mining and environmental engineering

Scientific and technological advances being sought in this area include

- airborne gravity gradiometry
- remote sensing and mineral mapping
- deep probing airborne and ground EM
- microbeam ultratrace and isotopic analysis.

Mineral Exploration and Mining

Integration and interpretation of data, and presentation of information for exploration, mining and environmental engineering

Scientific and technological advances being sought in this area include:

- interactive multi-dimensional visualisation
- causal inversion
- interactive haptic systems.

Mechanics of geological, excavation, extraction and materials handling processes

Scientific and technological advances being sought in this area include:

- algorithms for mine design, optimisation and scheduling
- time dependent behaviour of geomaterials
- characterisation of mine tailings and waste.

The control and optimisation of mining equipment and its interaction with the mining process

Scientific and technological advances being sought in this area include:

- control theory of compliant structures
- communications
- guidance and control
- condition monitoring and location.

Performance and evaluation measures

CSIRO's performance in meeting its statutory obligations and, more specifically, its contribution to the sector, will be evaluated against the following performance indicators, in consultation with the Sector Advisory Committee:

- customer and stakeholder satisfaction
- collaboration with other R&D providers
- financial (return on investment) and economic benefits
- research profile
- external earnings ratio
- generation and protection of IP.

Effective coordination and management of the sector process will depend on clear lines of communication and consultation between the various CSIRO divisions involved, particularly between divisional chiefs and the sector coordinator.

Sector coordinator

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email: j.read@dem.csiro.au

Divisional and other participation

Exploration and Mining (146.9 EFT), Telecommunications and Industrial Physics (7.3 EFT), Land and Water (14.7 EFT), Manufacturing Science and Technology (9.9 EFT), Wildlife and Ecology (3.6 EFT), Coal and Energy Technology (2.2 EFT), Mathematical and Information Sciences (2.0 EFT), Petroleum Resources (0.2 EFT), CSIRO Office of Space Science and Applications (0.1 EFT). CRCs: Australian Geodynamics, Australian Mineral Exploration Technologies, Landscape Evolution and Mineral Exploration, Mining Technology and Equipment. Key Centre for Geochemical Evolution and Metallogeny of Continents (GEMOC, Macquarie University), Centre for Isotope Studies, Australian Centre for Minesite Rehabilitation Research.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	16.6	17.1	16.9
External funding	15.4	15.8	16.0
TOTAL	**32.0**	**32.9**	**32.9**
External/total ratio	48%	48%	49%

Major Capital Assets

New Thermal Ionisation Mass Spectrometer, valued at $1m, chared with Petroleum Sector.

Mineral Processing and Metal Production

In compiling this foreword I am mindful of the need to the Sector and CSIRO as a whole to demonstrate clearly the value created for Australia by research in Australia.

CSIRO's contributions to the Mineral Processing and Metal Production Sector are valued by the industry. The Sector Advisory Committee has reviewed the Mineral Processing and Metal Production Sector and Component Research Plans and provided CSIRO with advice on the direction and specifics of the plans. We have endorsed the projected growth in non-ferrous mineral processing, base metal hydrometallurgy, precious metal production and environmental systems. In its environmental activities, CSIRO needs to bring a strong emphasis on "risk management" through coordination of environmental groups within CSIRO and the universities.

While the sector plans have been endorsed there are a number of concerns that the Advisory Committee has. These are:

- In order for benefits to be derived from the Sector process, the accountability of the Sector Coordinator and the contributing Divisional Chiefs needs clarification. Mechanisms for translating our advice into organisational actions will need to be developed and clear pathways for the CSIRO to market itself on a Sector basis should be established.
- There is a clear need to explore potential benefits from overlap with other related Sectors and mechanisms to achieve this should be established.
- The Sector Advisory Committee is concerned that a target of 45–50% external earnings by 1999–2000 may be unrealistic in the light of changes to R&D concessions and incentives. There should be no compromise of the quality of the science and engineering delivered in trying to meet this target.

Yours sincerely,

Ian Lawrence
Chair, Mineral Processing and Metal Production Sector Advisory Committee

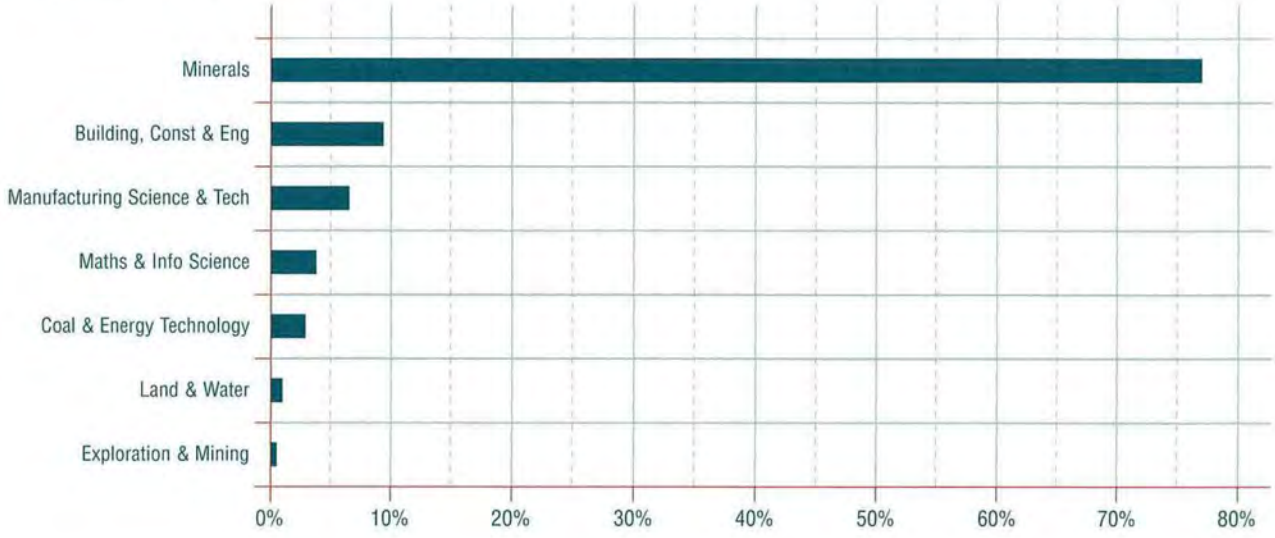
Mineral Processing & Metal Production Sector Advisory Committee:

Ian Lawrence (Chair), Western Mining Corporation; *Don Banfield*, Dept of Primary Industries & Energy; *Robin Batterham*, CRA Ltd and GK Williams CRC for Extractive Metallurgy; *Keith Crocker*, Dept of Industry, Science & Tourism; *Dick Davies*, Australian Mineral Industries Research Association; *David Debney*, Alcoa of Australia Ltd and AJ Parker CRC for Hydrometallurgy; *Mike Eager*, Aberfoyle Limited; *Ian Hartnell*, Queensland Metals Corp; *Robert Hobbs*, BHP Co Ltd; *Bruce Kelley*, CRA-Advanced Technology Development; *Jim Mitchell*, North Limited

Mineral Processing and Metal Production

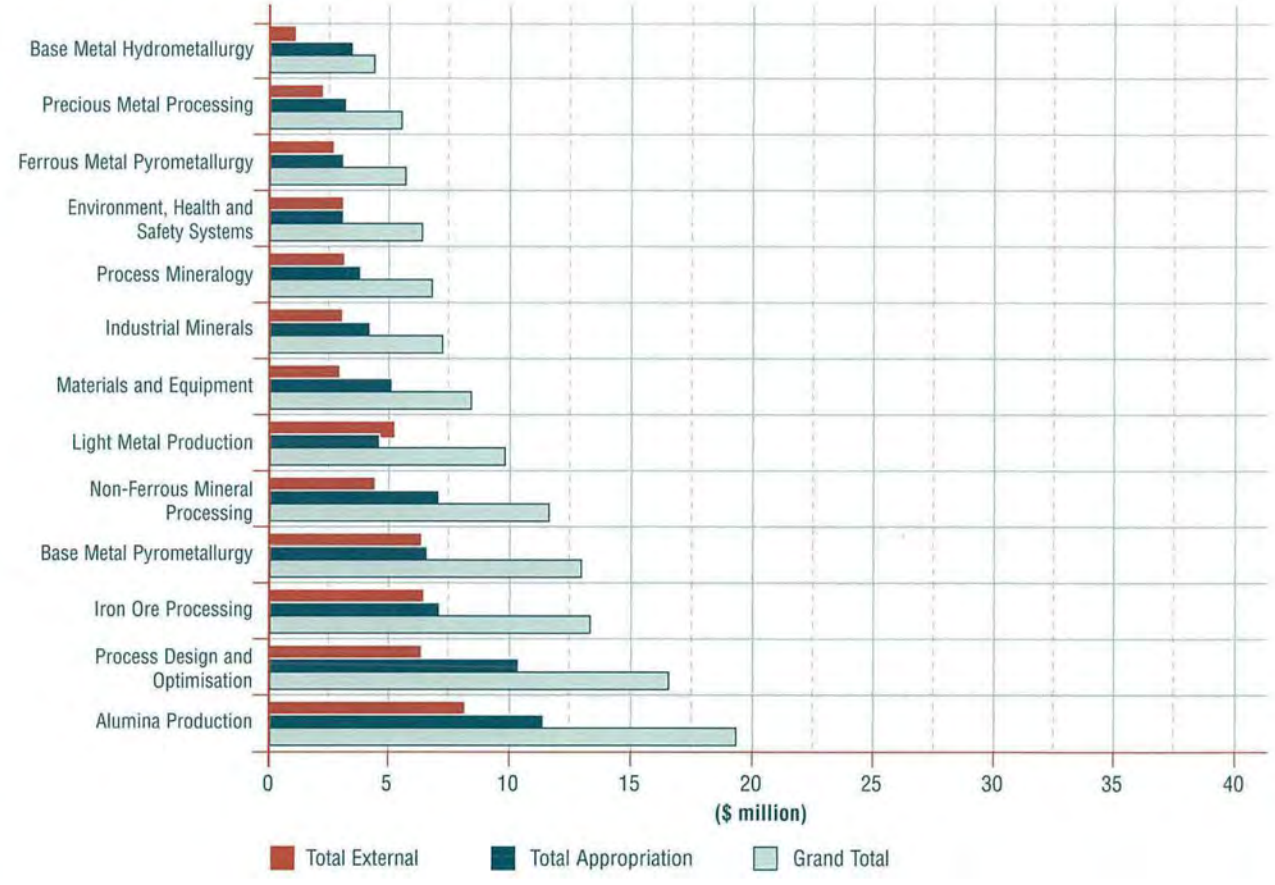
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $128.51 million)



Triennial Investment by Component

(Total Sector Investment $128.51 million)



Mineral Processing and Metal Production

Mission

To deliver R&D outcomes to the Australian mineral processing and metal production industries that will benefit their efficiency, product quality and value-adding prospects and to provide advice to government on environmental, occupational health and safety, and industry standards.

Overview

The sector relates to activities which transform as-mined inorganic mineral ores to:

- mineral products, usually concentrates, to be shipped to processing plants in Australia and overseas
- processed minerals in a relatively pure state, sold for intrinsic chemical value (e.g. alumina, titania, magnesia and industrial minerals)
- metal products sold in undifferentiated generic forms, such as ingot or rod.

The 1995–96 export earnings from the Mineral Processing and Metal Production Sector (the MP&MP Sector) was about $23 billion, which was 32% of all merchandise exported. The Industry Gross Product for 1994–95 was $10.3 billion. In 1994–95 there were over 500 companies operating in the MP&MP Sector in Australia, with 74 000 employees. The remote location of many mineral operations, and the significant service and supply side to their needs, gives a large multiplier to employment dependent on the mining and minerals industry.

Australian companies are well organised users of science and technology and they have an increasingly international focus.

R&D activities supporting the sector are characterised by multi-disciplinary effort encompassing chemical, chemical engineering, electro-chemical, physical sciences, mathematical and metallurgical skills. Complex mineralogy and metallurgical systems place great demands on sophisticated diagnostics, measurement and control at both a micro (e.g. molecular interaction) and macro (e.g. plant) level. Consequently, enabling technologies, such as computer software and instrumentation, are integral to success. Site-specific impacts on the local environment from the processes and their mitigation are an integral feature of the sector's operational characteristics.

The drivers for technological development in the sector are the changing environmental and social expectations placed on the industry and the need for it to remain competitive. These manifest as demands for:

- clean and green technologies
- radical and intense processing technologies
- smart sensors and remote control of processing.

Deregulation has forced companies in recent years to concentrate on short-term profitability and, as a result, the role of corporate R&D is being questioned. Another consequence has been the reduction of staffing levels and significant erosion of corporate memory. Internationalisation by many companies means that decision-making may move off-shore.

In this climate, the strategic R&D role of CSIRO is critical to Australian industry remaining world class. However, the reduced ability of companies to absorb technological innovations could be a major impediment to further productivity gains over the next triennium.

Governments, State and Federal, have responded to the same economic forces by reducing the size of the public sector. The ability of governments to make important planning decisions in the MP&MP Sector has been reduced, so that the strategic technical expertise of CSIRO is now of increased importance to other government agencies.

The overall strategy, therefore, will be to:

- carry out long-term research in areas strategically important to Australia
- facilitate technology transfer through short-term applied research using expertise and facilities developed through strategic research, and by partnering and collaborating with companies on long-term technology developments
- complement existing private research facilities and provide strategic underpinning
- contribute to coordination of public sector R&D
- provide technical advice to government agencies to assist with planning.

The Sector Advisory Committee has played, and will continue to play, a major role in establishing priorities and focusing the research activities.

Major objectives and key potential outcomes

The broad objectives are to:

- perform strategic research in areas critical to the future profitability of the MP&MP Sector
- directly support the technology development of the sector through the application of expertise and facilities, developed in strategic research, to problems of immediate concern
- assist companies to implement the developments from strategic research as opportunities arise
- promote the development of expertise within CSIRO, industry and academia through collaborative activities which strengthen and rationalise R&D effort

- develop an understanding of the principles of sustainable mining and minerals industry
- provide technical advice to government agencies on issues such environment, health and safety, and standards in areas of expertise.

The potential outcomes will include:

- incremental improvements leading to increased profitability and more efficient processes processing of otherwise uneconomic ores
- cleaner processes (end-of-pipe and whole process solutions)
- increased exports of commodities and value-added commodities
- technically informed government policy on sustainable development
- increased expertise within the metallurgical community
- development of new knowledge and understanding
- movement of highly trained CSIRO staff to industry and academia
- rationalisation and coordination of R&D effort at national level.

Some specific outcomes will be:

- the development of appropriate sciences and technologies for more acceptable processing options to foster sustainable development
- the development of methodologies and resources to provide a service to government and industry for advice, research and technology transfer on environmental aspects of mineral processing and metal production, including scientific input into national and international agreements and standards, and performance auditing for the industry
- support for the establishment of a direct iron-making industry in WA, and a magnesium industry in Queensland
- development of new environmentally-attractive biotechnological and solvent extraction and electro-winning extraction methods
- development and application of enabling technologies in fluid dynamics, and information technology especially relating to systems for handling and transferring large data sets
- development of measurement and control diagnostic systems especially associated with materials and equipment monitoring
- continued productive contributions to the Cooperative Research Centres program, in particular to the G. K. Williams and A. J. Parker CRCs
- better delivery of public sector R&D.

Customers, technology transfer and commercialisation

The MP&MP Sector has five types of clients:

- **Mineral companies with in-house R&D capability:** generally large, with growing international operations, these have well-developed technology strategies which include out-sourcing of R&D. They value CSIRO for its world-class people and facilities, often expect novelty and leading edge science and technology and may be interested in licensing intellectual property CSIRO has developed. Confidentiality is often paramount.
- **Mineral companies with limited in-house R&D capacity:** these vary from those having a strong innovative and entrepreneurial spirit to those running the risk of being overtaken by more technologically aware competitors. They value CSIRO's ability to provide a whole service which may be both more comprehensive and conventional compared with large companies. CSIRO's services may include intellectual property, advice on R&D strategy and acting as a facilitator for access to the wider technological world. Many of these customers are interested in consortia research.
- **Peak industry bodies:** the Minerals Council of Australia (MCA) is the peak industry body for developing policy, creating networks and liaising with government, opposition and community groups. The Australian Mineral Industry Research Association (AMIRA) is an industry body established to facilitate consortia research and development for the mining and mineral processing industry. Other industry associations of importance include the International Organisation for Standardisation (ISO), the International Lead Zinc Research Organisation (ILZRO), Nickel Producers Environmental Research Association (NPERA), and Copper Producers Association (CPA).
- **Consultants and suppliers to the sector:** this sub-sector is growing rapidly and is not yet well serviced by CSIRO. Such consultants and suppliers utilise specialised analytical services, have specific knowledge and process development and modelling skills. Their needs are short term and immediate.
- **Government:** Australian and State governments expect CSIRO to do long-term strategic research of value and to maintain world leading-edge excellence in R&D. They expect CSIRO to provide timely advice and fulfil a role in R&D areas such as the environment, health and safety, and in standards development where there is market failure to provide funding. DIST, DPIE, State government departments of minerals and resource development are important to CSIRO.

For convenience, the MP&MP Sector R&D market has been segmented into 13 commodity and discipline-based R&D programs. Each program aligns with a clear market and brings together relevant disciplines into groups of critical mass. A certain amount of overlap and ambiguity is inevitable in any segmentation of research and management is sensitive to this.

The major mechanism of technology transfer for the sector will be through research activities carried out collaboratively and through contract with companies or consortia of companies, such as AMIRA. In all cases, the technology transfer mechanism(s) will be planned at the stage of establishing the agreement and will be described in the work program.

Where agreed by industry, technical advisory panels will be established for appropriate programs to assist in developing collaborative activities with industry. The Research Advisory Committees of the G. K. Williams and A. J. Parker CRCs will also contribute in this respect.

Other technology transfer mechanisms will include publication and presentation of non-confidential results, and contributions by CSIRO staff to workshops, short courses and conferences.

CSIRO's Chief Executive Officer has set an external earnings target for this sector of 45%–50% of total earnings. This target assumes that external earnings can grow from their present level of 38%, as the industry absorbs new technology.

CSIRO expects to receive a fair return for its research. The pricing of research will be based on the perceived value to the client, and the value should always exceed the cost of carrying out the research.

Marketing and communication

CSIRO effort for the MP&MP Sector will be highly client-focused. Efforts will be made to ensure there is a commitment at all levels to respond to the market and to ensure processes are in place to determine market needs. As well, the performance of the sector will be monitored.

In line with the development of corporate policy, CSIRO will introduce the following:

- a customer satisfaction survey, to be carried out on all significant projects
- a project benefits survey, to be carried out on all significant projects at their completion (or yearly, for longer projects)
- a project portfolio review, to be carried out at regular periods to assess the balance of research areas and to identify new areas for appropriation investment.

A consistent approach will be adopted for all participating divisions. The findings will be analysed by the Market Development Group and appropriate feedback provided at all levels. The outcomes will be reviewed annually by the Sector Advisory Committee.

A key account management system will be introduced during the triennium.

A marketing communications program will be implemented to ensure clients are aware of CSIRO capability and to draw attention to new developments. This will include a widely-distributed newsletter, press releases, articles for trade journals, leaflets and brochures describing particular expertise, participation by CSIRO researchers in conferences, and the organisation of conferences, workshops, seminars, etc. on selected topics.

CSIRO's policy is to assist Australian industry, but with increasing globalisation it is necessary for researchers to be international in outlook in order to remain world class. CSIRO will need to consider its role in providing R&D within this context during the triennium; the advice of the Sector Advisory Committee will be critical in determining sector policy.

Development of CSIRO's R&D capacity

R&D activities in the sector have been ascribed to eight fundamental scientific and engineering disciplines, each represented by an eminent 'senior scientist'. These disciplines run across the 13 programs; they provide a 'home' discipline to scientists who are otherwise assigned to different programs as projects come and go. The current key science and engineering discipline areas are:

- mineral processing
- mineralogy, solid state chemistry
- electrochemistry and electrometallurgy
- hydrometallurgy
- metallurgy and chemistry of high temperature systems
- process instrumentation
- process design, control and optimisation
- industrial flows.

The **senior scientists** devote about 25% of their time to this activity. Their role encompasses the development of science plans, provision of specialist advice to project teams, mentoring of staff, advice on recruitment and capital procurement, organisation of conferences, and the benchmarking of skills through science audits.

New initiatives will be implemented during the triennium, such as Senior Visiting Fellowships, R&D secondments and Postdoctoral Research Fellowships. The recently inaugurated Innovation Awards will be continued. Major involvement in the A. J. Parker and G. K. Williams CRCs will be enhanced, leading to

increased participation in postgraduate training and development. Experience in technology transfer will be promoted through cooperative exchange arrangements.

Key focus areas for scientific and engineering advances have been identified from the Science Plans and the Generic Industry Research Themes. The market needs and scientific and engineering opportunities are

Clean and green technologies

- fine particle generation, behaviour and control
- mixing and granular flow optimisation
- *in-situ* and bio-leaching
- radioactivity removal and stabilisation
- recovery of metals from wastes
- light metal production
- industrial ecology.

Radical and intense processing

- reaction thermodynamics and kinetics at high temperature
- materials design and synthesis for aggressive environments
- numerical and experimental thermo fluid dynamics
- selective liberation of ores
- direct conversion of concentrates and iron ores
- powder, vapour and plasma phase metallurgy
- biotechnology and novel hydrometallurgical catalysts
- nanotechnology and molecular simulation, especially of interfaces
- fluidised bed technology.

Smart sensors and remote control

- process visualisation, modelling, design and optimisation
- neural networks, expert systems and self-learning algorithms
- on-line sampling and sorting technologies
- mathematical operations research, especially statistical process control
- decision support techniques
- information technology and management of large databases
- new sensor technologies.

Performance and evaluation measures

- **level of customer satisfaction**, assessed by clients, according to agreed sector guidelines; on-going (collated and reported yearly)
- **benefits** to industry, to Australia and to CSIRO, assessed by the relevant Division, according to agreed sector guidelines (on-going, collated and reported yearly)
- **external income** (target: 45% to 50%), assessed by corporate CSIRO (yearly, in July).

These measures include the performance indicators required for CSIRO formal reporting, but are considerably broader. The Sector Advisory Committee will review all performance data yearly.

Sector coordinator

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Divisional and other participation

Minerals (187.0 EFT), Building, Construction and Engineering (21.0 EFT), Exploration and Mining (0.5 EFT), Land and Water (3.0 EFT), Mathematical and Information Sciences (9.4 EFT), Manufacturing Science and Technology (14.2 EFT), Coal and Energy Technology (6.8 EFT). CRCs: G. K. Williams, A. J. Parker, CAST CRC Mineral Processing Laboratories. Postgraduate students.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	23.1	25.0	25.6
External funding	15.6	18.5	20.8
TOTAL	**38.7**	**43.5**	**46.4**
External/total ratio	40%	43%	45%

Major capital items (>$250 000), subject to further evaluation and prioritisation by the sector participants and the Sector Advisory Committee:

- pilot-plant for bio-leaching, SX and EW
- X-ray imaging of high temperature systems
- melt levitation facility
- plasma torch for pilot-plant smelting
- continuous pressure leaching pilot plant
- XRF fusion equipment.

Petroleum

As the world increases its demand for secure supplies of energy, especially clean energy such as gas, the oil and gas industry is increasing its exploration and production investment. For example, the global offshore oil and gas industry is forecast to increase its annual upstream expenditure by 24% to over US$100billion in 1999, with the Asia-Pacific region attracting much of this investment. Here in Australia, we are clearly still at the frontier of an exciting future on the North West Shelf and in the Zone of Cooperation, especially as we move into greater water depths. Our undeveloped gas resources also offer a huge national advantage if we can find innovative, cost-efficient and environmentally acceptable ways of bringing them to market. This presents us with a clear technical challenge.

But there are other challenges. The risks and costs are high: over the past five years in Australia and the Zone of Cooperation, only 1 offshore well in 5, each costing about A$10m, produced a technical discovery, with considerably fewer commercial discoveries. More significantly, high operating and capital costs, together with the cost of failed exploration, set against a background of low oil prices and a substantial burden of primary and secondary taxation, lead to an inadequate after-tax return on funds employed of 11% for the Australian industry. Given that little can be done to control the price of oil or the appetite of government for taxation revenue we clearly require the development of new technologies if we are to have a successful upstream petroleum industry in Australia.

Our industry is committed to keeping environmental impact within sustainable limits, but nevertheless is facing national greenhouse responsibilities and an increasing public focus on the potential impacts of its activities on the marine environment. Despite the outstanding record of achievement by the Australian industry to date, these issues must be managed pro-actively through the application of the "license to operate" from the Australian public and overcome the often misguided view that ours is a low-tech environmentally unfriendly business.

The industry expects CSIRO take a lead in developing Australia's strategic technology base by developing its own capabilities and by networking with other R&D organisations. We are clearly pleased to see CSIRO increase its commitment to the petroleum sector which will help it satisfy this role. Against this background, the industry welcomes the opportunity to engage in a "smart partnership" with CSIRO. In particular, it very strongly endorses CSIRO's approach to involve the industry in the setting of its strategic directions and the framing of its investment decisions.

The process to arrive at the business plan for the Petroleum Sector has been constructive. In particular, I am pleased to see projects to address the potential impact of the industry's operations on the marine environment and these have been integrated with APPEA's R&D strategy. The process has also provided an important opportunity to take a forward look at the skill base the industry expects CSIRO to have into the future. The Committee strongly endorses the objective of strengthening CSIRO's capabilities in the directions outlined in the sector plan, to draw on the capabilities in various "discipline" divisions and especially to develop an Australian seismic geophysics capability in conjunction with Curtin University.

On behalf of the Committee, I would like to say that we are committed to both our role and the sector processes and we look forward to a productive and mutually beneficial partnership.

Yours sincerely,

Agu J. Kantsler
Chair, Petroleum Sector Advisory Committee

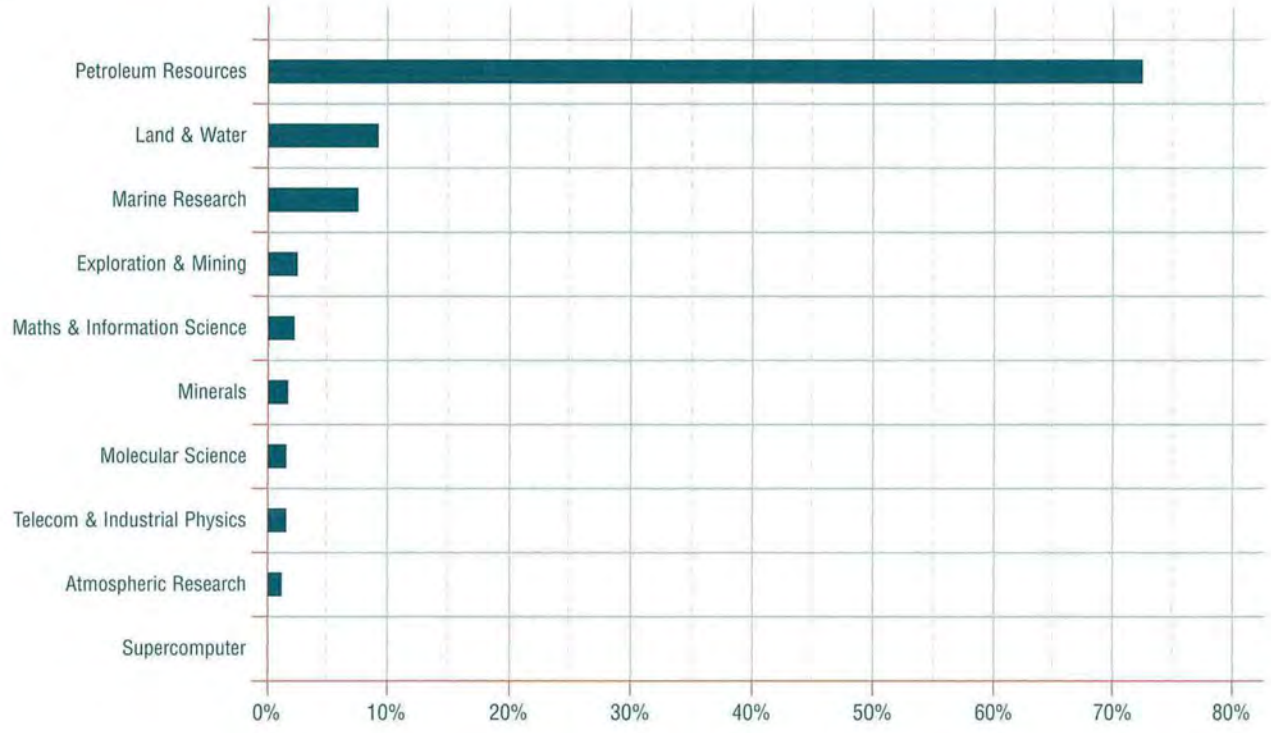
Petroleum Sector Advisory Committee:

Agu Kantsler (Chair), Woodside Petroleum Ltd; *Frank Aquino*, Woodside Offshore Petroleum Pty Ltd; *Charles Balnaves*, BHP Petroleum Pty Ltd; *Peter Goode*, Santos Ltd; *Rodney Halyburton*, BHP Petroleum Pty Ltd; *Eve Howell*, Apache Energy Ltd; *John McPherson*, Mobil Exploration & Producing Australia Pty Ltd; *Rob Male*, Woodside Offshore Petroleum Pty Ltd; *Michael Sayers*, West Australian Petroleum Pty Limited; *Robert Willink*, Boral Energy Resources Ltd

Petroleum

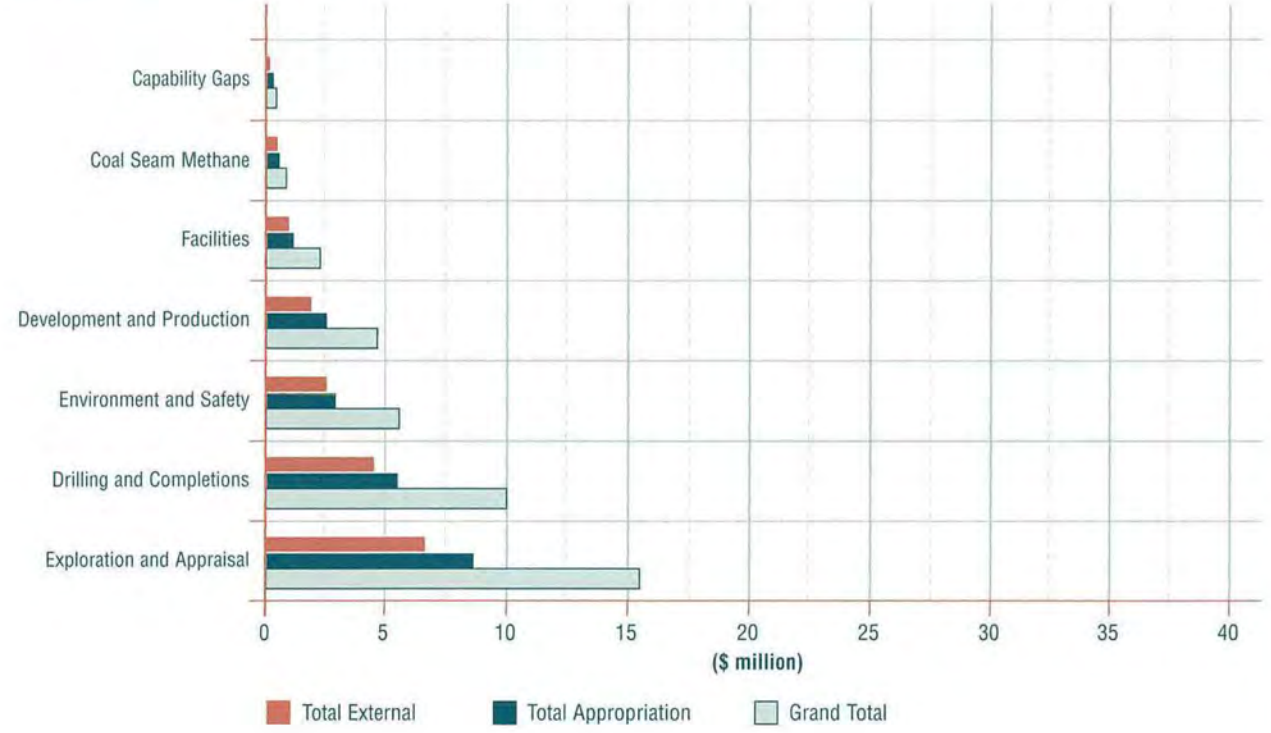
Divisional Commitments to Triennial Sector Budget

(Total Sector Investment $41.33 million)



Triennial Investment by Component

(Total Sector Investment $41.33 million)



Mission

The industry and CSIRO share the vision that CSIRO, with its associated institutions, will be the leading research provider to Australia's oil and gas industry. In this context, CSIRO's mission is to work with the industry and a global scientific network to identify the need and opportunity for new technology solutions, and deliver the strategic research, technologies and services required.

Overview

Significance of the sector

A competitive and profitable oil and gas industry is a national priority. The sector:

- supplies 53% of Australia's energy needs
- is developing a $250 billion resource
- has an added value of $17 billion a year.

Significance is increasing as world-class gas resources are integrated into the Australian and regional economies, enhanced by industry restructuring and the demand for clean energy.

Scope

The sector covers exploration and production through to the processing and distribution of petroleum products. It includes coal seam methane, administered under the *Petroleum Act*. It is concerned with safety and the environment, especially the marine environment.

Industry R&D outlook

The petroleum industry is facing a period of fairly flat prices within a volatile band, while costs are rising. These pressures, and a demand for a wider range of technologies, are forcing companies to down-size their internal R&D capabilities in favour of outsourcing and collaboration. Against this trend is the increasing role in technology development of service companies and government laboratories, and the R&D capabilities developing in national oil companies such as Petronas in Malaysia. Associated with this global restructuring is an increasing concern that the industry is losing its sources of strategic research.

These trends have significant positive impact on the opportunity and role for CSIRO.

Major objectives for industry and CSIRO

The Australian industry is driven by three groups of objectives, which will determine its needs for new technology and CSIRO's directions. Particular objectives are:

Public and work-force responsibility

- to keep the impact on the environment within sustainable limits, ensure access and avoid inappropriate regulation, focusing on the marine environment, air quality and greenhouse effects
- to provide a safe and healthy environment.

Exploration and production

- to reduce exploration risks and costs and increase economic discovery rates, with a focus on the Zone of Cooperation
- to improve the appraisal of new discoveries by reducing uncertainty about reservoir architecture and production potential
- to improve the profitability of existing and new developments, by reducing the capital and operating cost of facilities, improving the delivery of wells and optimising the management of reservoirs
- to ensure that the enabling capability exists to support exploration, development and production in frontier areas and in increasingly deep water
- to extend the economic life of maturing fields or basins by extending production and finding new associated pools
- to turn marginal discoveries into economic reserves through low-cost novel solutions.

Natural gas

- develop the opportunity offered by deregulation of gas supply and distribution
- develop technologies to radically improve the movement of gas and the transportablility of gas energy.

Overriding these objectives is the need to access new technologies rapidly. This is a special issue for Australia given its remoteness from the major technology centres in the world. It includes awareness of new technologies, best practice and the removal of local barriers to their adoption.

Benefits

Successful research directed towards the major objectives outlined will see:

- a more profitable petroleum industry, supplying most of Australia's energy and continuing to expand internationally
- increased community benefits extending far beyond the value added directly by the industry, for example:
  - every $100 of production generates an additional $80–140 of value to the rest of the economy, a multiplier effect of 1.8 to 2.4 (Australian Bureau of Agricultural and Resource Economics, 1996)

— the petroleum industry is responsible for the generation of $11 billion a year in taxes

- an industry operating in a way which ensures a sustained environment
- realisation of extensive natural gas resources.

Major strategies

CSIRO will:

- continue to develop its plans and make its commitments as a partner with the industry
- take a global view of science and technology
- draw on the capability in divisions across CSIRO and extend CSIRO's capability through its Australian and global network. This includes working with the Australian Petroleum Cooperative Research Centre (APCRC), the Australian Geodynamics CRC (AGCRC), the Centre for Isotope Studies (CIS), the Australian Geological Survey Organisation (AGSO) and the Australian Institute of Marine Science (AIMS)
- increase its capacity in defined areas, to enable it to respond to the industry's high priorities
- build closer relationships with service companies, especially in the development of products
- pursue development of the industry's R&D strategy.

External consultations

The sector and component plans have been developed from:

- component level discussions between research leaders and industry people, which produced a draft set of issues and desired outcomes
- a meeting of the Sector Advisory Committee, which built on the planning by essentially the same committee working with the APCRC over the past five years and the component level discussions. The meeting produced ranked priorities
- an awareness of the R&D strategies of individual Australian companies and internationally of the USA and Europe
- an awareness of global research activity.

Major objectives and outcomes

CSIRO's objectives and targeted outcomes are based on priorities agreed with the Sector Advisory Committee.

Environment

The focus will be on the marine environment, with greenhouse and clean air issues being addressed by the Climate and Atmosphere Sector. Objectives, which will be integrated into the Australian Petroleum Production and Exploration Association's (APPEA's) initiatives, are:

- to appraise the impact of particular industry operations on the marine environment
- to assemble baseline marine ecosystem data
- to develop an optimal monitoring program
- to reduce uncertainty in the methods and procedures associated with project acceptance.

The outcome will see an industry operating to sustain both the environment and the profitability of the industry, with environmental issues being decided on sound knowledge.

Exploration

The major objective is to improve exploration success rate. The focus will be on:

- improving the quality of seismic imaging
- improving geological and petroleum system models for a basin or target discovery.

Success will see the addition of new reserves which determine the future of the industry.

Appraisal

The objective is to reduce uncertainty by developing technology to improve:

- delineation of discoveries
- definition of reservoir architecture including compartmentalisation
- appraisal of key production parameters such as permeability and residual saturation.

Success will improve development decisions.

Production

Objectives focus on tools necessary to manage reservoirs and on the determinants of production, especially:

- the internal distribution of production determining parameters such as relative permeability and porosity, recognising heterogeneity on the pore to reservoir scale
- the significance of faults and fractures which enhance or compartmentalise reservoirs
- the up-scaling of dynamic parameters.

Success will improve recovery and the profitability of companies.

Drilling and completions

Objectives are to:

- remove barriers to adopting new drilling concepts, especially for horizontal and multi-lateral wells, and to reduce unproductive costs

- develop system tools which access global experience, increase learning capacity and enable optimisation of well construction
- solve wellbore stability and formation damage problems associated with drilling fluids
- develop technologies for real-time decision making e.g. seismic-while-drilling
- develop ability to quantify in-situ stresses.

The outcome will be improved well productivity and lower costs.

Facilities

The major objectives, which focus on the north-west marine environment, are to:

- identify the major phenomena, such as internal currents and eddies, and to develop the data base and calibrated models required to determine extreme event wave and current loadings on facilities
- develop the data base and calibrated models which quantify sediment movement.

The result will be a reduction in the uncertainty of design loadings and the need for remedial works.

Information

The petroleum industry is characterised by sparse and diverse data which needs to be integrated. The objective is to:

- develop information integration platforms
- develop technologies which support the integration of data at different scales and from different sources.

The outcome will improve communication across disciplines; especially it will radically improve the efficiency and speed with which a company can make decisions, and thus the competitiveness of the Australian industry.

Coal seam methane

The major objective is to support the establishment of this embryonic industry by developing:

- exploration models targeting 'free' gas
- technology which will underpin the reliable estimation of recoverable reserves and production to bankable document standard
- production-stimulation technologies which will deliver economic production rates.

Complex processes

The major objective is to:

- develop technologies which describe complex, human-dependent processes, e.g. appraisal.

The result will be a radical improvement in the planning, strategic decision-making and learning capability within companies.

Customers, technology transfer and commercialisation

Customers

The sector's customers include:

- petroleum companies, including the major and small companies and multi-national companies
- service companies which support the petroleum industry
- Federal and State Government departments and their agencies such as the Energy Research and Development Corporation (ERDC) and the Minerals and Energy Research Institute of WA (MERIWA).

Special stakeholder relationships exist with the peak associations, APPEA and the Australian Institute of Petroleum (AIP).

Technology transfer and commercialisation

Plans for each issue map out CSIRO's role and the mechanism(s) for commercialisation. The plans aim to maximise impact and recognise:

- the need for rapid transfer to operating companies, which usually sees collaborative or prototype service relationships
- the role of service companies in product development, distribution and support
- the need in some cases for CSIRO to develop and offer a specialised service.

Marketing and communication

Major marketing objectives are to:

- continue the integration of Australian R&D into the global technology development fraternity through key relationships with
  - — the overseas laboratories of the major operating and service companies
  - — the emerging research arms of the national oil companies, such as Petronas and the Japan National Oil Corporation (JNOC)
  - — overseas networks such as the Petroleum Science and Technology Institute (PSTI)
- increase the petroleum R&D culture within the industry, government and CSIRO, and maximise CSIRO's contribution to the industry by
  - — briefing CSIRO divisions on the outlook and

needs of the petroleum industry, and briefing particular companies on the capabilities within CSIRO
  - — the development of focus groups with industry and CSIRO in key areas
  - — promoting achievements and their impact.

Development of CSIRO's R&D capacity

During the past six years, CSIRO has built a capability and addressed particular priorities with notable achievements. Its present capacity is about half the targeted level. The present position with respect to the major objectives identified is that:

- new skill bases need to be developed through redirection and recruitment regarding
  - — seismic geophysics
  - — complex and dynamic processes/systems
- capability needs to be assembled mainly from existing skills to address the following:
  - — integration of sparse and diverse information
  - — physics and formulation of drilling fluids
- existing capacity needs to be strengthened in:
  - — reservoir characterisation and processes
  - — drilling processes
  - — near wellbore phenomena and engineering
  - — coal seam methane exploration and production.

Natural gas

While it is clear that Australia has a fortunate endowment of natural gas, the national strategy and technologies required to fully realise it are not apparent. Analysis will be pursued with the Coal and Energy Sector to understand the national strategy and identify the R&D required.

Other issues

CSIRO has the potential to address other significant issues, e.g. advanced materials required in new compressor developments and pipelines. These issues need further exploration to identify the precise role for CSIRO.

Performance and evaluation measures

Performance improvement

Three activities will underpin performance improvement:

- the introduction of small, highly-focused technical forums with invited participants
- interviews at the end of contracts
- continued annual reviews of performance against the major plans by the Sector Advisory Committee (in conjunction with the APCRC reviews).

Internal management

Issue Plans, at a level finer than Component Plans, will detail strategies, targeted new knowledge, commercialisation and responsibilities for the issue. At the operational level, interdivisional project agreements will be used where more than one division is involved.

Performance evaluation

Performance will be appraised against the Sector and Component Plans, and the Sector Advisory Committee will be invited to participate.

Sector coordinator

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Divisional participation

Petroleum Resources, Exploration and Mining, Marine Research, Minerals, Land and Water, Telecommunications and Industrial Physics, Mathematical and Information Sciences, Molecular Science, Atmospheric Research.

FINANCIAL SUMMARY

	($ million)		
	1997–98	1998–99	1999–2000
Appropriation funds	7.3	7.8	7.8
External funding	5.7	6.2	6.5
TOTAL	**13.0**	**14.0**	**14.3**
External/total ratio	44%	44%	45%

Major Facilities

- petrophysics laboratory $250,000
- drilling fluids laboratory $350,000
- thermal ionisation mass spectrometer $1 million (with Exploration and Mining Sector)
- drilling processes laboratory $300,000

Appendix

The CSIRO assessment framework

The CSIRO Executive considered the organisation's existing R&D investment portfolio in August and September 1996, following presentations on socioeconomic trends and scientific opportunities for the sectors at the CSIRO Sector Outlook Forum in August 1996. Decisions were made on:

- whether the existing investment portfolio should change over the next triennium and beyond, and if so
- for which sectors should funding grow, decline, or stay steady
- desirable levels of external funding for each sector, and desirable levels of CSIRO's appropriation resources investment.

The assessment framework for this task is shown below and on the next page. The diagrams represent:

The return to Australia assessment: the relative attractiveness and feasibility of R&D for the sectors.

This assessment is neither an end in itself nor a way of automatically deriving 'correct' resourcing for sectors. It is only a means for identifying and discussing relevant data and information in a structured and comprehensive way.

Assessment is based on relative values, not absolute ones. Each criterion must be assessed independently; taken in any order. The result of this phase of the assessment is presented in the form of three charts (see next page).

CSIRO response: role and investment strategy—the level of CSIRO effort in the national context and the desired mix of appropriation and external funding.

Account must be taken of strategic factors judged to be important for CSIRO to realise its overall mission. The result of this phase of the assessment is presented on page 140.

The Executive's decisions, together with messages and challenges arising from the deliberations, were produced for internal use as 'CSIRO's Strategic Research Directions' and conveyed to divisions and the Sector Advisory Committees in late September 1996.

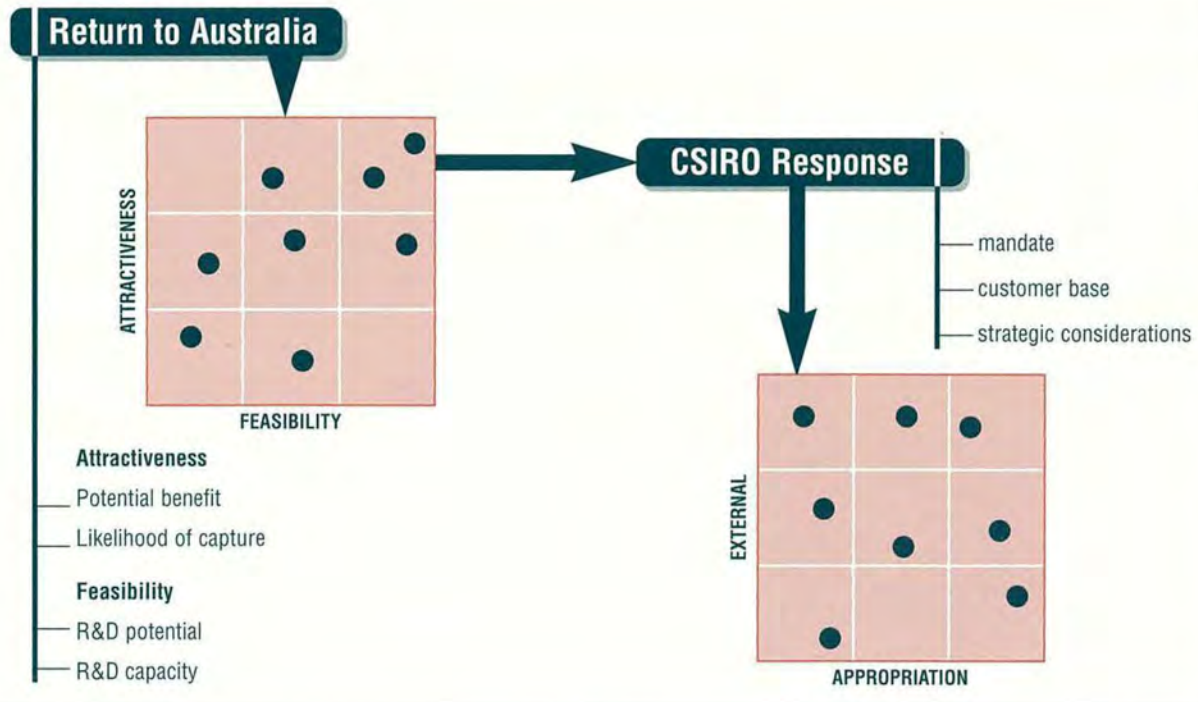
The output from this process is a set of Sector Plans, each consisting of a five-page overview and up to ten or so two-page Component Research Plans. Only the Overview section of each Sector Plan is included in the *CSIRO Strategic Research Plan, 1997–98 to 1999–2000*.

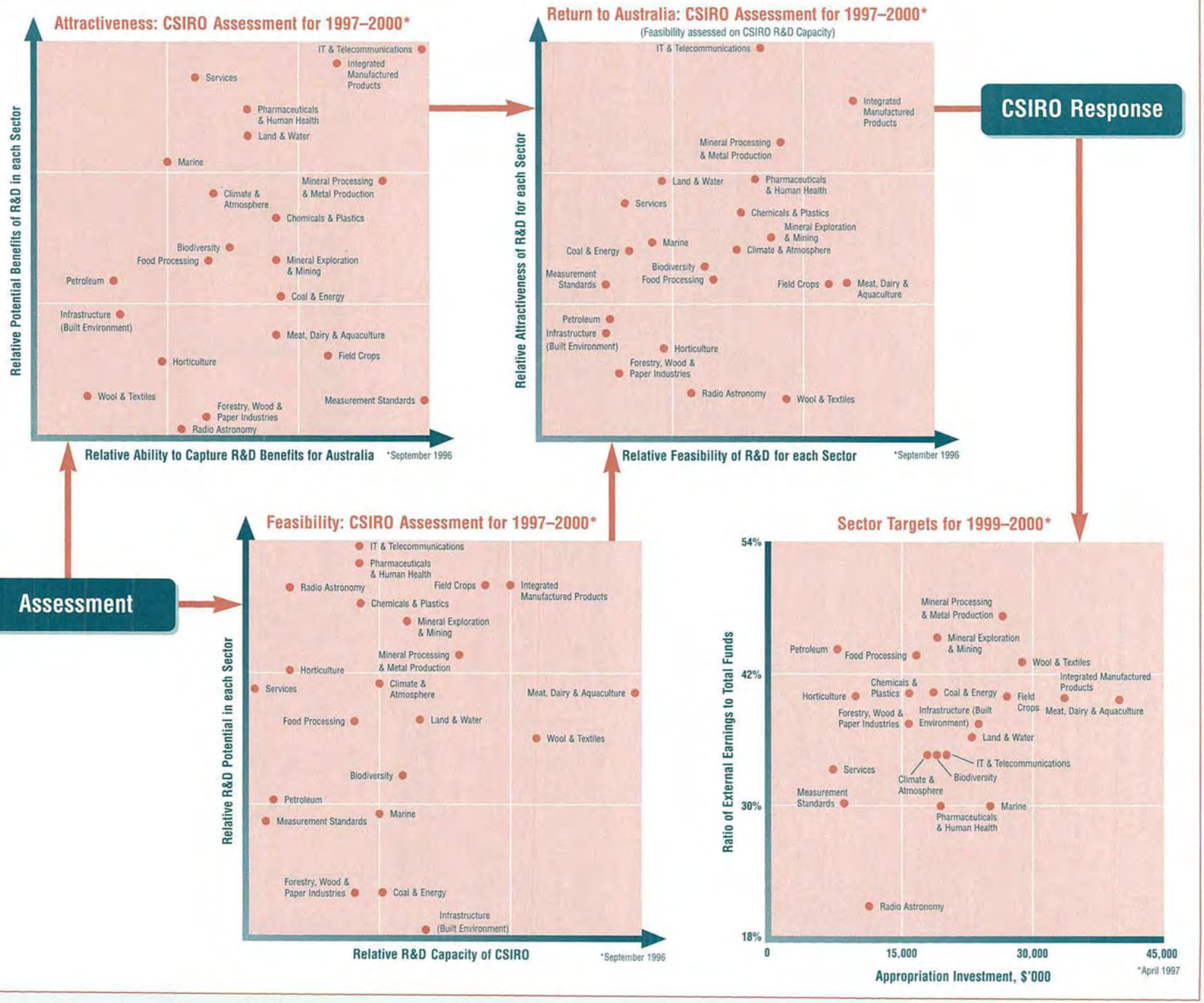
I. The return to Australia assessment

Attractiveness

How, and to what extent, does Australia in general, and do CSIRO's customers in particular, benefit from scientific and technical advances relevant to the sector? This assessment is based on two criteria: potential benefit and ability to (or likelihood of) capture. The second criterion is a probability function of the first, so

The CSIRO Assessment Framework




Attractiveness: CSIRO Assessment for 1997–2000*
Relative Potential Benefits of R&D in each Sector
IT & Telecommunications
Integrated Manufactured Products
Services
Pharmaceuticals & Human Health
Land & Water
Marine
Mineral Processing & Metal Production
Climate & Atmosphere
Chemicals & Plastics
Biodiversity
Food Processing
Mineral Exploration & Mining
Petroleum
Coal & Energy
Infrastructure (Built Environment)
Meat, Dairy & Aquaculture
Field Crops
Horticulture
Wool & Textiles
Measurement Standards
Forestry, Wood & Paper Industries
Radio Astronomy
Relative Ability to Capture R&D Benefits for Australia
*September 1996
Return to Australia: CSIRO Assessment for 1997–2000*
(Feasibility assessed on CSIRO R&D Capacity)
Relative Attractiveness of R&D for each Sector
IT & Telecommunications
Integrated Manufactured Products
Mineral Processing & Metal Production
Land & Water
Pharmaceuticals & Human Health
Services
Chemicals & Plastics
Mineral Exploration & Mining
Marine
Coal & Energy
Climate & Atmosphere
Biodiversity
Measurement Standards
Food Processing
Field Crops
Meat, Dairy & Aquaculture
Petroleum
Infrastructure (Built Environment)
Horticulture
Forestry, Wood & Paper Industries
Radio Astronomy
Wool & Textiles
Relative Feasibility of R&D for each Sector
*September 1996
CSIRO Response
Assessment
Feasibility: CSIRO Assessment for 1997–2000*
Relative R&D Potential in each Sector
IT & Telecommunications
Pharmaceuticals & Human Health
Radio Astronomy
Field Crops
Integrated Manufactured Products
Chemicals & Plastics
Mineral Exploration & Mining
Mineral Processing & Metal Production
Horticulture
Services
Climate & Atmosphere
Meat, Dairy & Aquaculture
Food Processing
Land & Water
Wool & Textiles
Biodiversity
Petroleum
Marine
Measurement Standards
Forestry, Wood & Paper Industries
Coal & Energy
Infrastructure (Built Environment)
Relative R&D Capacity of CSIRO
*September 1996
Sector Targets for 1999–2000*
Ratio of External Earnings to Total Funds
54%
42%
30%
18%
Mineral Processing & Metal Production
Mineral Exploration & Mining
Petroleum
Food Processing
Wool & Textiles
Integrated Manufactured Products
Chemicals & Plastics
Horticulture
Coal & Energy
Field Crops
Meat, Dairy & Aquaculture
Forestry, Wood & Paper Industries
Infrastructure (Built Environment)
Land & Water
IT & Telecommunications
Services
Climate & Atmosphere
Biodiversity
Measurement Standards
Marine
Pharmaceuticals & Human Health
Radio Astronomy
0
15,000
30,000
45,000
Appropriation Investment, $'000
*April 1997

that the scores for the two criteria are multiplied to give the 'Attractiveness' score.

1. Potential benefits

What, and how large, are the potential economic, social and environmental benefits from successful research conducted for the sector? The size of these benefits is calculated from the estimated marginal impact of R&D, by comparing the 'with research' situation for the sector (research successfully completed and adopted) and the 'without research' prognosis.

CSIRO needs to consider

- all possible research opportunities, not only CSIRO's traditional research activities
- that Australia conducts only 2% of global R&D and that access to, and benefits from, the remaining 98% are highly important
- the competitive impact of technology on an industry
- that reduced or avoided costs are a form of benefits.

Indicators

Factors to bear in mind include:

- **Size and growth of target sector:** The size of the potential benefits is determined significantly by the size of the target market. Benefits flow in the future, so potential benefits are influenced by future size, which can be estimated from growth trends.
- **Productivity increases:** R&D frequently leads to productivity increases—reduced cost of production and/or increase in quantity produced.
- **Increase in exports and reduction in imports.**
- **Global R&D intensity:** This is a pointer to the benefits of R&D for a sector, as perceived by other nations and firms.
- **State of the environment:** This indicates benefits that could accrue from restoring degraded natural resources or protecting them from degradation.
- **Impact on other sectors:** Any spillover benefits or costs (such as pollution) should be added to (or subtracted from) the potential benefits for the sector.

2. Australia's ability to capture

What is the likelihood of Australia capturing the potential benefits? The likelihood is determined by factors such as industry structure and global competitiveness and the willingness of firms, resource agencies or individuals to take up the R&D. An understanding of the industry structure, say by vendor pyramid analysis, may be used to determine where the maximum benefits to Australia may be generated.

CSIRO needs to consider

- who the potential research users are and how they will capture benefits (by what mechanisms?)
- local versus overseas adoption of the technology
- factors (other than R&D) necessary to realise the benefits from successful R&D, e.g. distribution networks and marketing skills
- public acceptance and legislative issues.

Indicators

Factors to bear in mind include:

- **Competitive technological position:** For a particular industry this is reflected by its:
  - **market share:** More competitive firms have greater ability to capture benefits (one indicator is the share of target markets relative to competitors)
  - **industry structure:** In industries with many small firms each may be less able to capture R&D benefits compared to industries with more concentrated ownership
  - **level of innovation in the recipient firm or area:** Data is available from the Australian Bureau of Statistics on levels of innovative activities in various sectors of the economy
  - **Australia's R&D effort:** R&D intensity (the ratio of gross R&D expenditure to the value of production or sales) indicates receptiveness to R&D; the size of R&D effort by firms indicates the degree of technical competence.
- **Customer type:** Different customers, e.g. public (government, agencies), private (SMEs, large enterprises) and rural industry corporations, have different sorts of scientific and technological requirements.
- **Export or import intensity:** High ratios of exports to production or low ratios of imports to production, help indicate competitiveness (but may reflect high levels of protection or assistance).
- **Uniqueness of problems to Australia:** This is attributable, most often, to environmental or natural resource problems.
- **Existence of supporting government policy for the sector:** The ability to capture may be higher in sectors which have targeted support.
- **Public good research:** Spillover of benefits to overseas users doesn't reduce benefits to Australian users, so the ability to capture is high.

Feasibility

How feasible is it for CSIRO and its partners to achieve the scientific and technical progress that the sector requires? This assessment is also based on two criteria: R&D potential and R&D capacity. The second criterion is again a probability function of the first, so that the scores for the two criteria are multiplied to give the 'Feasibility' score.

Appendix

1. R&D potential

The questions to ask are what overall rate of progress in scientific understanding and technologies is likely for the research considered in identifying the potential benefits? Where is current technology on the S-curve—the 'technological maturity'? Is technical progress rapid, moderate or slow?

Indicators

Factors to bear in mind include:

- **Excitement and enthusiasm in the research community:** The appearance of new, international conferences in particular fields is one sign.
- **Patents and publications:** Note the numbers and trends in relevant fields of science and technology.

2. R&D capacity

How strong is the existing capacity of CSIRO and existing, or likely, collaborators to perform the required R&D and achieve the R&D potential in a timely and competitive fashion?

The capacity should be judged relative to other research performers anywhere in the world. What is CSIRO's competitive position globally?

CSIRO needs to consider

- what particular skills and experiences are needed?
- can nationally or internationally competitive research teams be assembled?
- is the necessary research infrastructure (i.e., the equipment, buildings and other facilities) in place?
- has CSIRO developed a strong intellectual property position?

Indicators

Factors to bear in mind include:

- **Number of research groups with international standing and critical mass:** This may be judged by factors including patents and publications, invitations to international conferences, invitations to participate in international research consortia, etc.
- **R&D expenditure:** Overall magnitude of the R&D effort can be important.

II. CSIRO response: role and investment strategy

Having determined the relative attractiveness and feasibility of research for the sectors, decisions are then required on the role that CSIRO should play, in the context of other public and private sector research agencies.

Thus, an assessment is made on:

- the overall level of effort CSIRO should devote to each sector
- the mix of appropriation funds and external income for the sector.

This assessment is based on discussions dealing with:

1. Questions of mandate

- Does CSIRO have any specific responsibilities or restrictions? Examples of responsibilities are (legislated) measurement standards and national facilities; some restrictions apply to defence and clinical medical research.
- What other public sector research agencies operate in the sector? In terms of CRCs operating in the sector, what should the CSIRO contribute?
- Are there general government policies or obligations bearing upon the level or kind of effort in CSIRO?

2. Customer base

- What does the nature of the customer base (i.e., the users or potential users of CSIRO's research results) imply for the role of public sector R&D? Within this, what does it imply for CSIRO's role? (CSIRO must also take account of the role of other public sector research agencies.)
- The target balance between contract research (with transfer of intellectual property) and collaborative research (with shared costs and risks and shared IP). This discussion point may have particular implications for the target ratios of external funds/total funding.

3. Strategic considerations

CSIRO needs to consider

- the balance between delivery to customers in the short-term and maintaining and developing expertise and the disciplinary skills base
- the balance of R&D effort required between sectors to satisfy the skills base
- political and other considerations not specified above.

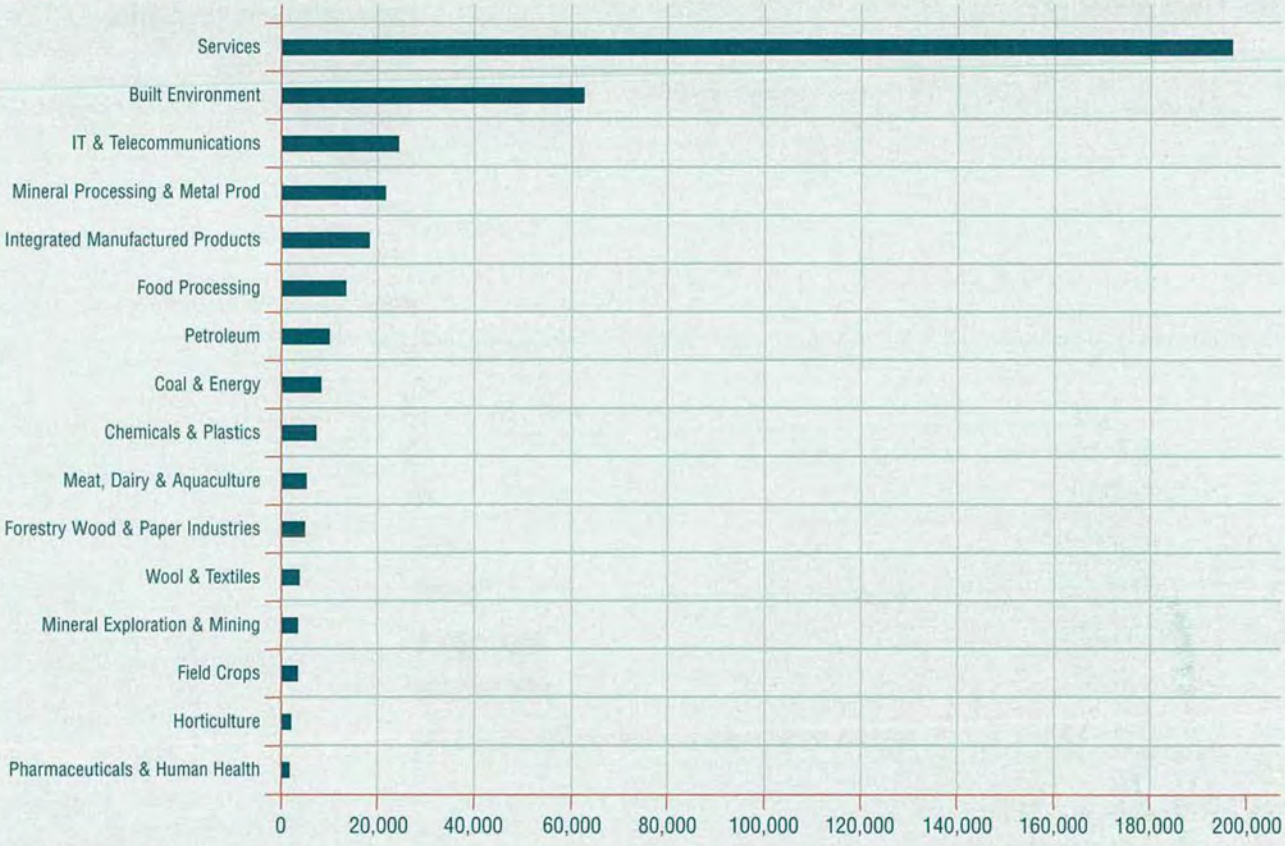
III. Indicator data

The deliberations on attractiveness and feasibility were influenced by data on a selected set of indicators. Such data is only available for the production-based sectors. Judgements were used to rank the non production-based sectors within this relative scale.

A summary of some of the indicator data used is shown on the following pages. All the national data were obtained from the Australian Bureau of Statistics.

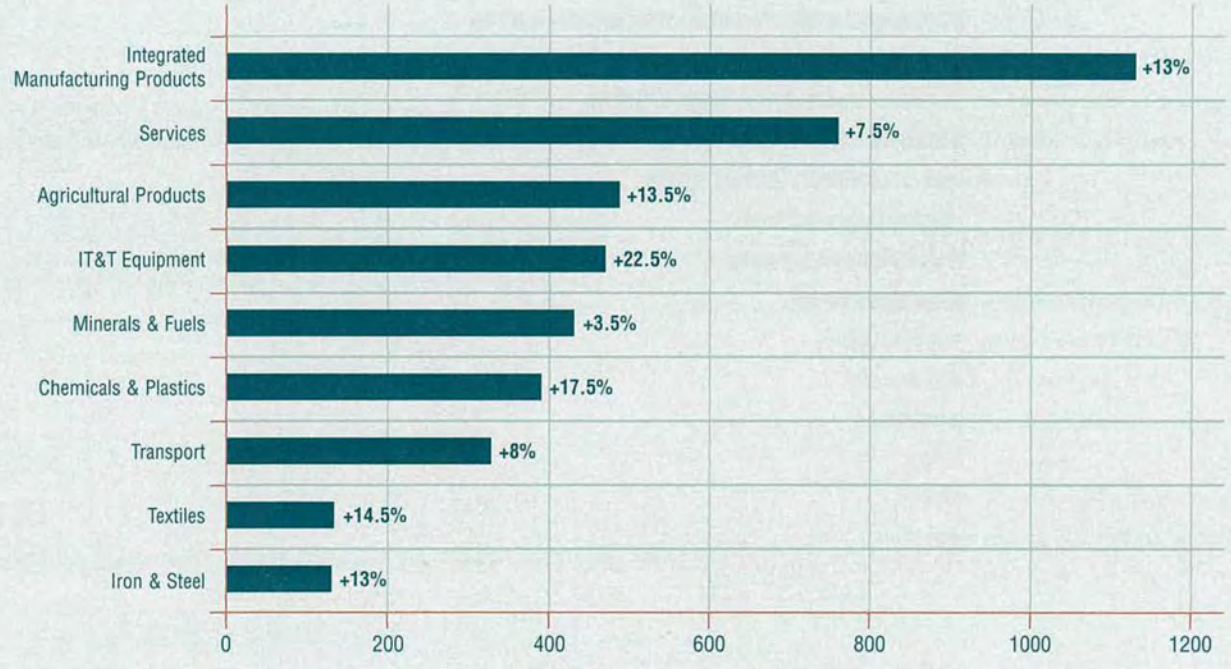
Value Added (Share of GDP) in 1992–93

($million—total is $384 billion)



Value and Growth in World Trade in 1994

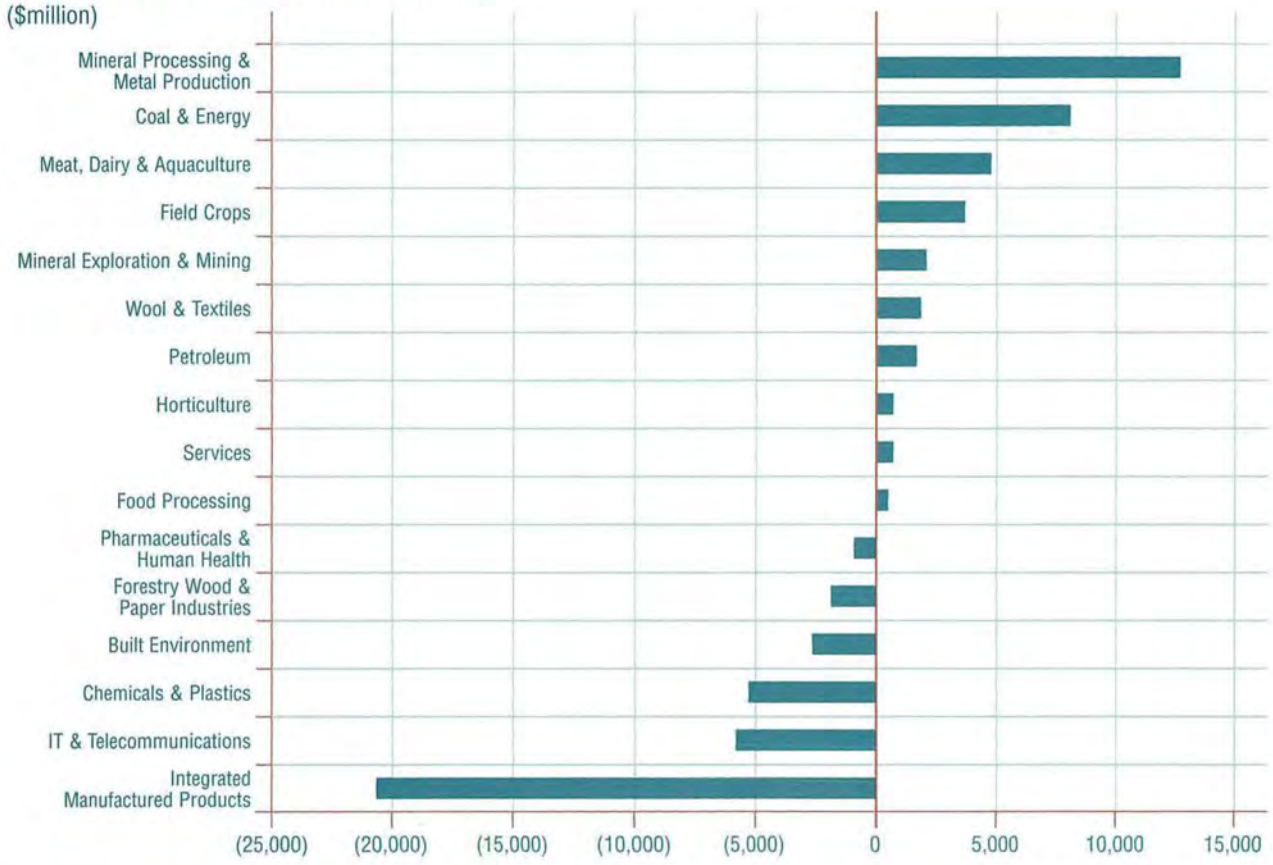
(US$billion)



Appendix

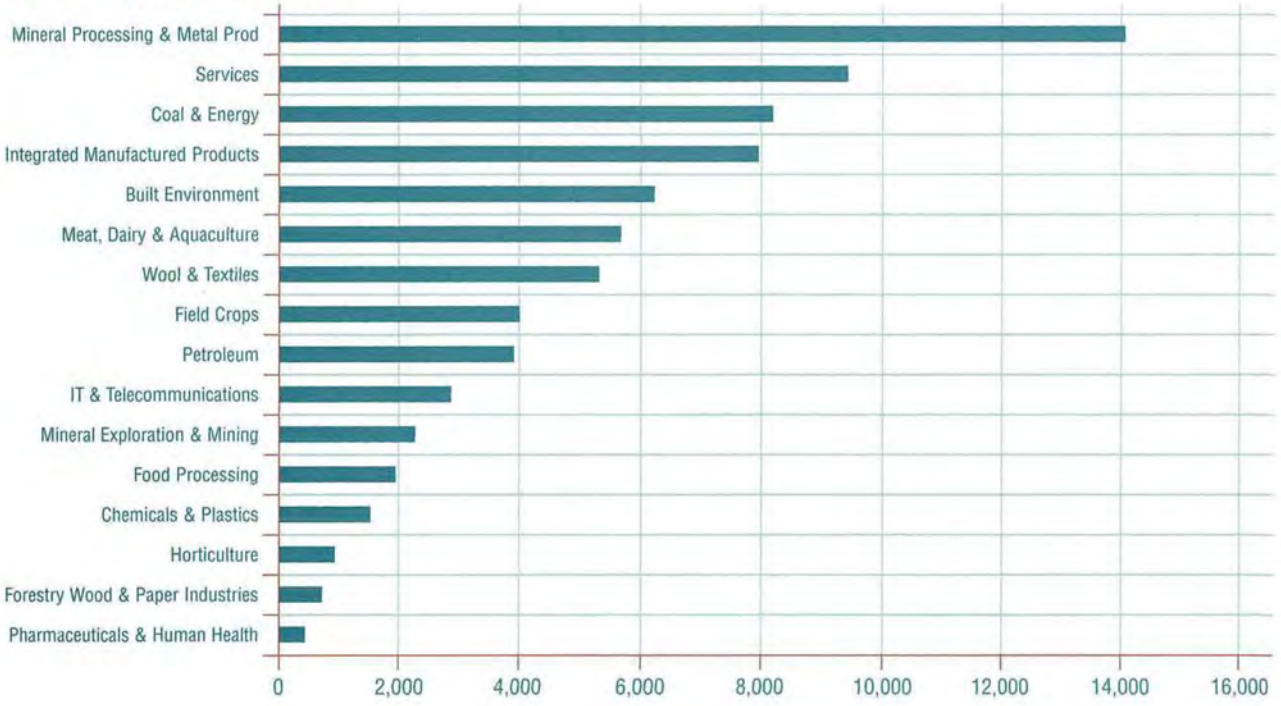
Net Trade (Exports–Imports) in 1992–93

($million)



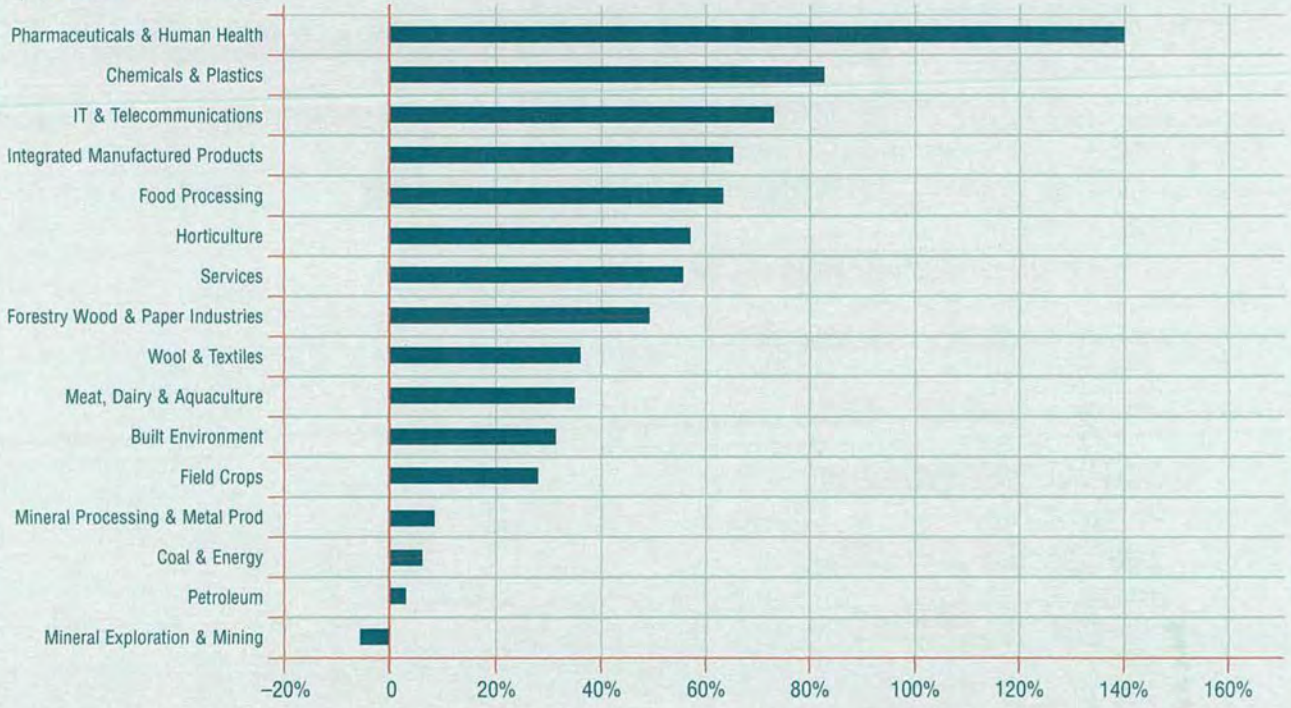
Value of Exports in 1992–93

($million—total is $75.8 billion)



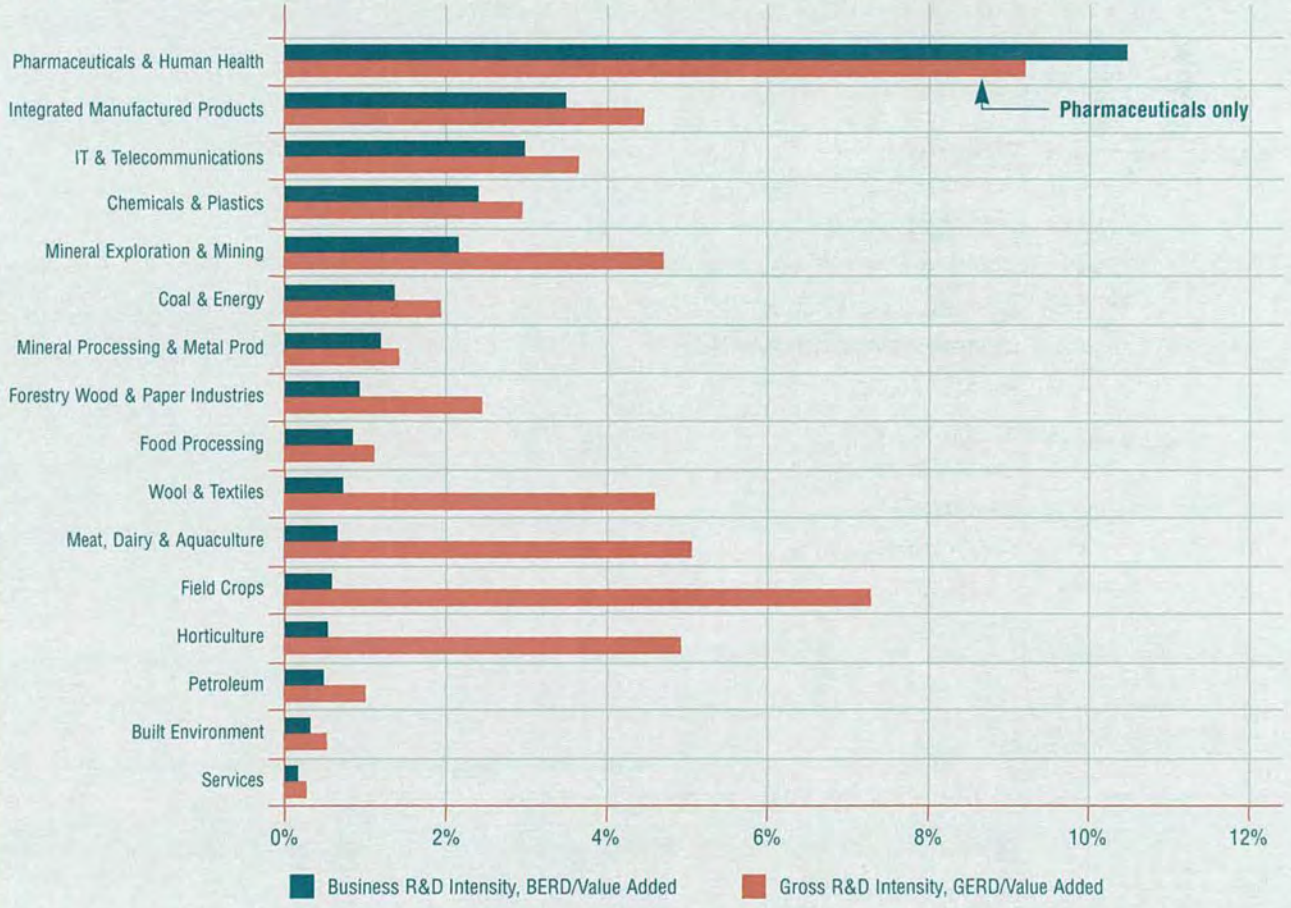
Growth in Exports from 1990–1994

(not adjusted for inflation)



R&D Intensities in 1992–93

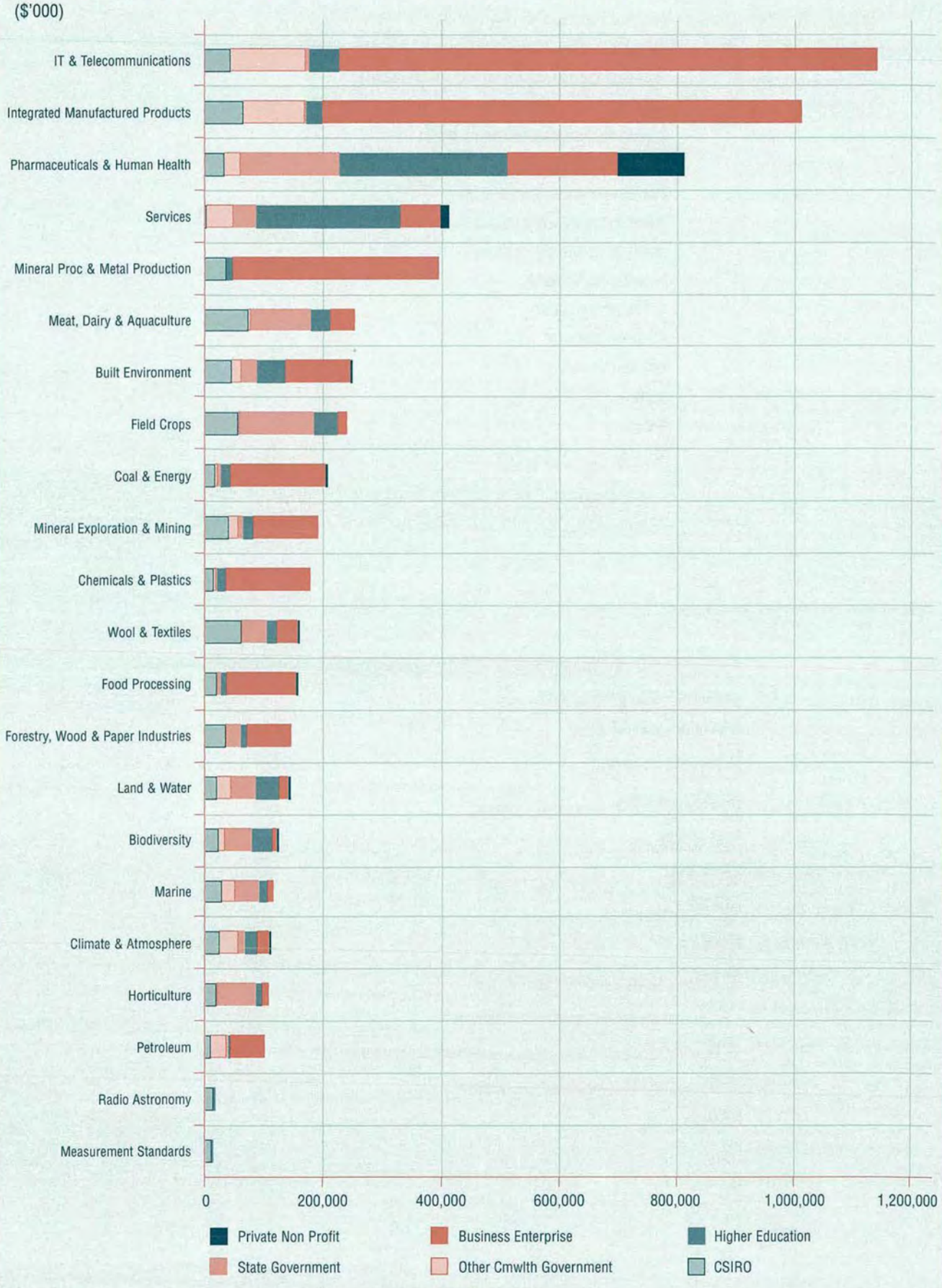
(Expenditure on R&D per Value Added)



Appendix

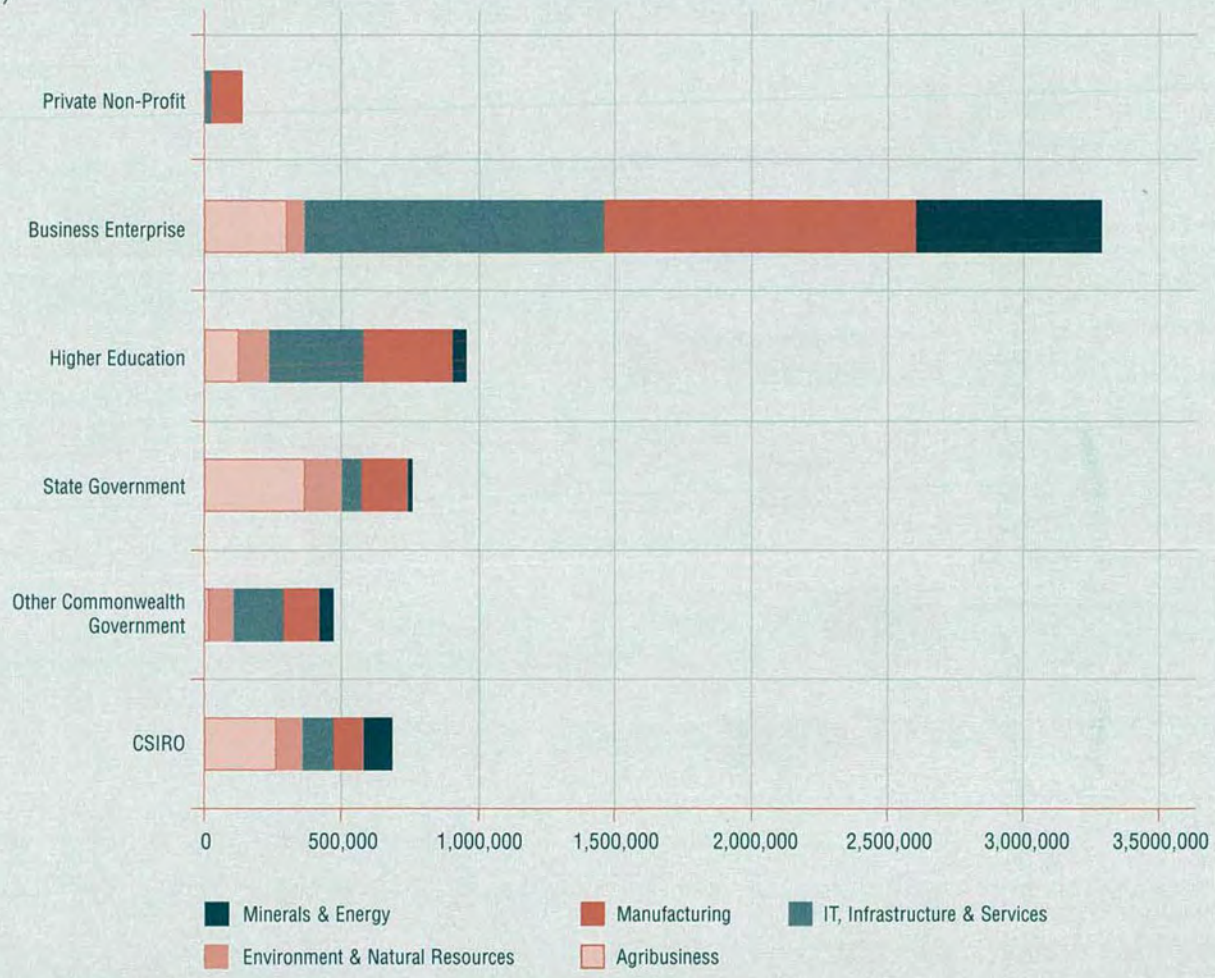
Gross Expenditure on R&D by Performer and CSIRO Sector in 1994–95

($'000)



Gross Expenditure on R&D by Performer and CSIRO Sector Grouping in 1994–95

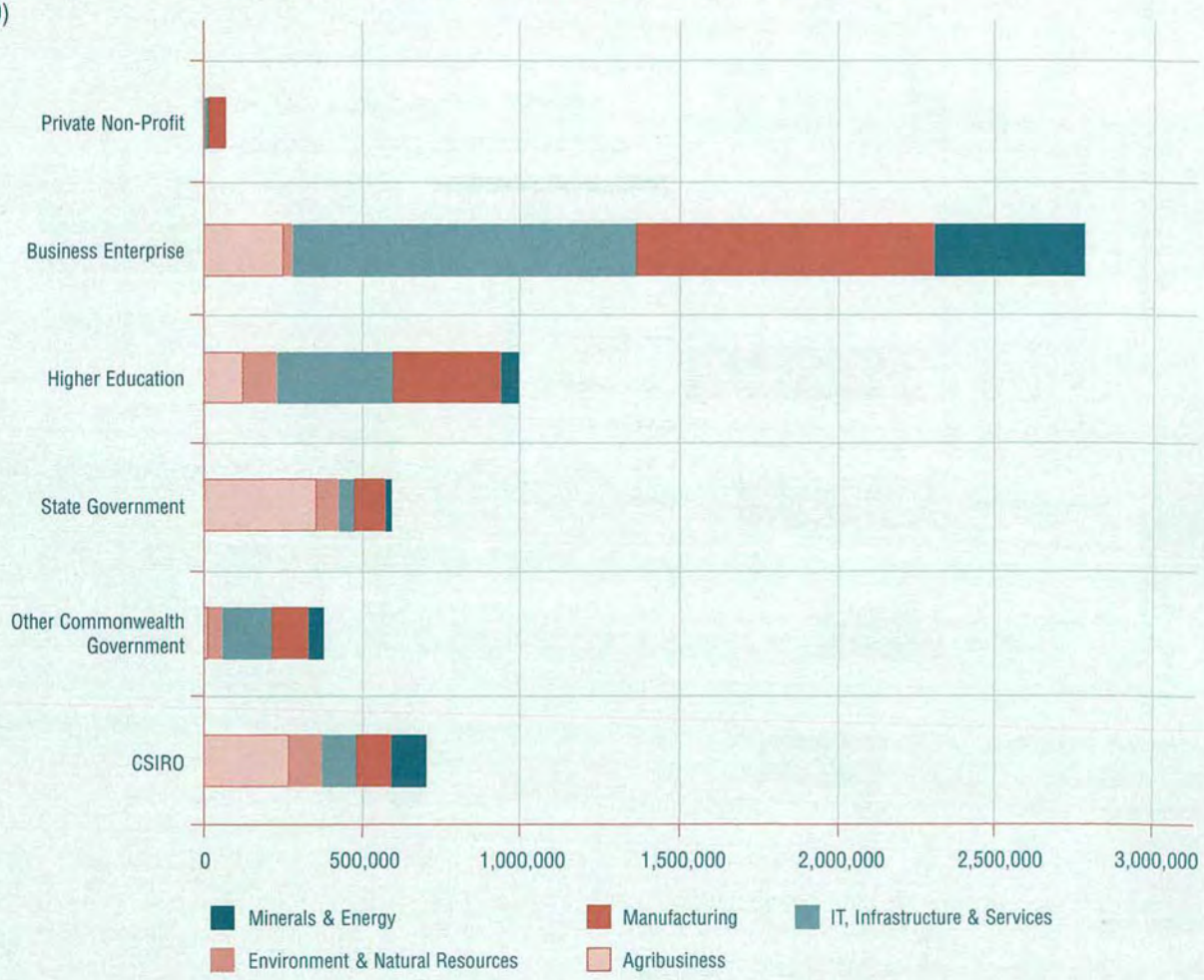
($'000)



Appendix

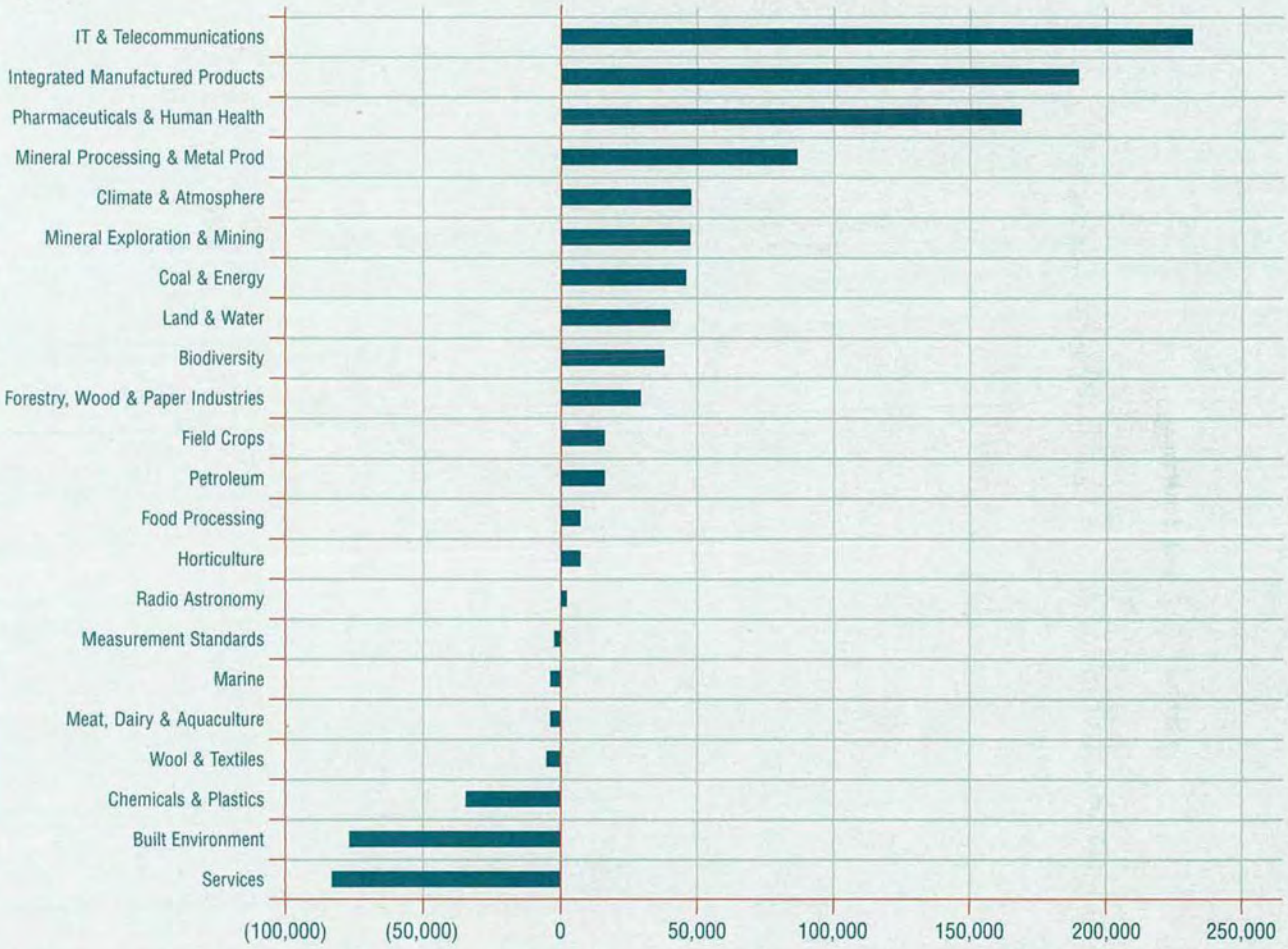
Gross Expenditure on R&D by Performer and CSIRO Sector Grouping in 1992–93

($'000)



Change in Gross Expenditure on R&D in Australia from 1992–93 to 1994–95

($'000)



Our Purpose

We serve the Australian community through outcomes which provide:

benefit to Australia's industry and economy

environmental benefit to Australia

social benefit to Australians

support to Australia's national and international objectives

through excellence in science and technology, and in the provision of advice and services.