Productivity Commission Inquiry: Implementation of Ecologically Sustainable Development by Commonwealth Departments and Agencies

CSIRO research serving sustainability

A CSIRO overview of the environmental and related research underpinnings of sustainability

November 1998

Preamble

CSIRO contributes strongly to achievement of Ecologically Sustainable Development (ESD) outcomes through relevant research and through the application of its outputs.

On that basis, CSIRO contributed significantly to the 1990-92 ESD Working Group processes and is addressing now the Productivity Commission's interest in the progress of programs with a direct impact on achievement of ESD. This submission focuses on CSIRO's contribution and, particularly, on how its environmental research serves sustainability outcomes in an increasing array of sectors.

("Sustainability" is used as a short-hand reference throughout to balancing economic and environmental goals in a long-term societal context –Page 4 elaborates).

In responding to an earlier questionnaire, CSIRO dealt with the Productivity Commission's interest in internal management measures which help CSIRO to behave sustainably as an agency.

This submission is based on two closely related streams of research undertaken by CSIRO:

- work to **understand** the environment and its processes, so that we can **protect** it
- **using** this environmental understanding **in partnership** with community, business and government towards meeting society's goal of ecological and economic sustainability.

The first is about understanding the ecological side of ESD. The second deals with the core of ESD, harmonising economic and environmental objectives. The two are equally essential contributions to sustainability: it is vital both to understand environmental matters and to bring brings this to bear on economic and social matters. To focus on one and not the other would be to adopt an unbalanced approach to research supporting ESD, and to policy, program, and management aspects of ESD itself. Since CSIRO works across this spectrum, it is familiar with the issues, and aware of the need to avoid pressures which could bring about a lack of full and balanced to attention to all relevant factors.

In some quarters, "environment" and "ESD" are used almost interchangeably. This is a misconception which can tend to lessen attention to environmental considerations as such, and thus threaten the achievement of ESD outcomes over the longer term.

Progress has been made in adopting ESD principles in a range of sectors (if, in some cases, rhetoric might outstrip reality). A challenge before Australia is to maintain momentum in all fields to achieve sustainability underpinned by adequate and evolving knowledge. Overall (if not necessarily in every instance), ecological, economic, social and cultural factors must link as integrative approaches.

Integrative approaches to ESD are crucial: providing them is a difficult but worthy challenge.

An associated challenge is to monitor and evaluate progress. Initiatives, such as State of the Environment reporting at different jurisdictional levels, have developed in recent times in welcome ways. But there is scope for enhanced evaluation action and for better, more practical measures which give timely feedback on progress at all scales from local to global.

Despite worthwhile steps forward, it is not yet sufficiently clear whether many activities are becoming more or less sustainable. This knowledge is crucial to good management.

Understanding changing issues and responding systematically is a critical base for effective research. CSIRO notes that its own planning and priority setting processes, by being comprehensive and participative (with key stakeholder representation), pay attention to ESD considerations. CSIRO commends participative approaches which bring together researchers and those concerned with application considerations to ensure that research remains relevant.

As the final part of this submission, CSIRO lists several research activities and approaches of particular value to ESD: examples of recent or current relevant activity are included as Attachments.

Annotated Contents

1. Overview of issues and needs in sustainability research.

In helping build essential environmental knowledge, and applying it to problems in many Sectors, CSIRO has concluded that the important factors and principles are:

- Growing demands for environmental outcomes in all sectors drive sustainability research needs.
- Environmental research alone will not provide sustainability solutions. Science must unite with socio-economic considerations to give robust solutions which are readily accepted and used.
- Gaining benefit from Australia's unique environment has relied on world class science tailored to local needs. Australia must also respond to global issues.
- Sustainability increasingly requires multidisciplinary approaches including the joining of natural and physical sciences with the social sciences and economics. Ways to enhance holistic solutions, and case studies to help develop and demonstrate such approaches, should be supported.
- Researchers need to be well linked with users and managers, from policy development to the on-ground level, extending well beyond formal funding relationships. As one important instance, there could be better ties between researchers and some Natural Heritage Trust (NHT) programs.
- Planning and priority setting at agency and economy sector levels needs continuing development (with transparency and maximum interaction of all parties). More is needed at cross-sectoral and broader levels: directive planning at these levels has limitations, but an occasional forum to discuss national needs in a sustainability context could assist planners, funders and performers.
- Evaluation processes - for policies, programs, and their research inputs - are mostly inadequate.
- The evolving diversity of Australia's research community has strengths. But, with many small-scale performers, there is lack of focused capability to provide the scale and length of effort which complex environmental/ sustainability issues often need. CSIRO achieves this in-house at times or, frequently, with others: but, overall, more cooperation and coordination is needed.
- Fundamental information gathering and environmental knowledge development continues to be strongly needed in targeted areas - the marine zone is one example. The disciplinary basis of science remains a powerful requirement: some weaknesses may be evident, such as in taxonomy.
- Effective progress on complex problems needs integrating frameworks, skills and teamwork. Challenging needs include integrative approaches to global and climate change, and to catchment, marine and other regional approaches; attention to adaptive systems; data capture and interpretation; and, rebuilding the environment (these and more are elaborated in Section 9).
- Research on environment-economy interactions and the application of environmental knowledge towards sustainability in many sectors has been inadequately funded but has grown in recent years.
- While Australia has strong capability in environmental research, investment in that base may be inadequate to maintain necessary strategic strengths and to satisfy growth in demand.
- The diversifying demand and funding can benefit responsive research performers. But satisfying shorter term needs, perhaps for sectional interests, must be balanced against the need for public agencies to serve the total and long term public interests which ESD encapsulates.
- In sum, important research-related responses to meet perceived ESD needs could include:
  - better teams pursuing integrative approaches, linking scientific and socio-economic factors
  - stronger two-way linking of policies and programs with research activity - for mutual benefit
  - opportunities to debate and develop broad guiding national overviews
  - more collaboration between Federal, State, tertiary-based and private sector research programs
  - continuing attention to particular strategic knowledge and skill gaps
  - adequate funding and support for independent and credible public benefit research
  - more attention to research supporting forward-looking management, not just for "repairs".

2. Key drivers of Sustainability Research into the 21st Century

A major demand - international, national and local - is that social, economic and ecological factors be harmonised for solutions that meet multiple objectives and can be sustained over a long period. CSIRO responds to the research needs of production sectors and of environmental resources and, so, addresses matters of sustainability daily. In doing so, it considers a complex, changing and highly inter-related mix of technologies, markets, values and uses. The breadth of the range may surprise those who wrongly believe that science tries to push on the basis of its own imperatives rather more than it responds. The shorthand list below of contextual issues is elaborated a little in Attachment A.

2.1 Internationalisation

This includes such matters as: new trade regimes; privatisation; "competitive neutrality"; demands for higher environmental quality; international environmental meetings, agreements and institutions (seminally in this area, the UN's Rio Summit and ensuing Commission for Sustainable Development); growing international travel; spread of exotic pests and diseases; global security, including possibilities of eco-terrorism; and real and perceived global inequalities.

2.2 Population growth, lifestyles, and demands for sustainability

This includes such matters as: food, shelter and resource requirements with continuing population growth; the effect of different and rising living standards; human health and ecological health; urbanisation; equity and access; achieving ecologically sustainable development.

2.3 New technologies and understanding

This includes such matters as: evolving technologies including particularly gene technologies; information, communication and data handling technologies contributing to "the knowledge revolution"; industries based on environment technologies; multi-disciplinary research.

2.4 Demands for planning and accountability

This includes such matters as: planning, priority-setting and accounting in participative and transparent ways; developments in corporate governance; community demands; ethics and values; industry accreditation, including through ISO approaches; openness and peer review.

2.5 Changing research structures

This includes such matters as: enterprises becoming more involved in research to meet environmental obligations; changes in private sector R&D capabilities with privatisation of utilities; continued expansion of the global networks of science; a growing range of research performers; and, with diversification, a flourishing range of collaborative arrangements.

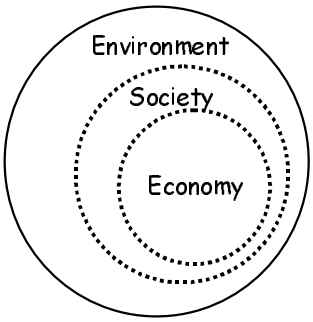
In sum, sustainability research sits in a wider context of issues which draw on, and affect, the environment. Research needs should be considered against a thorough analysis and understanding of their economic and societal context.

Domestic and global changes in trade systems, land use arrangements, commercial practices, tax, social relationships, and in the services and standards that society demands - all of these, and more, are relevant to decisions on environmental research.

Above all, ESD research must be fully integrated with the policies, programs and management it serves. It is one part of all of this, not an optional add-on.

3. Environment - one part of sustainability

The single word "sustainability" is used here to refer to the balancing of economic and environmental goals in a wide, long-term societal context. Its achievement requires attention to all factors. Environmental factors have to be explored and understood in their own right, to the extent possible (we are talking about humans in their physical surroundings, so a complex interplay is involved). Only with environmental knowledge in hand should trade-offs be made - a process of dynamic interaction with other aspirations, notably (but not only) attention to matters economic.



- Above is one view of the conceptual relationships behind sustainability. Cultural aspects are part of societal considerations.

Sustainability is not the starting point for trade-offs; it is the end point. It is neither an environmental goal - something for environmental interests to control - nor an economic goal such as growth. It is an optimisation or compromise process in a broad social-cultural context. Properly done, it gives the best possible long-term answers. There is some tendency to appropriate the sustainability concept to refer almost exclusively to either an environmental or an economic goal. This tendency is to be regretted.

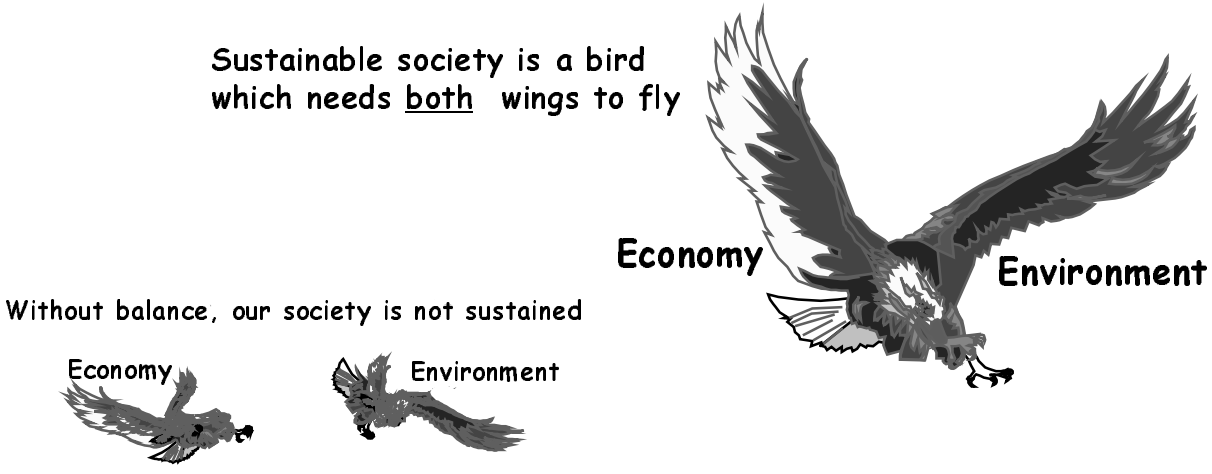
CSIRO accepts ESD concepts and sustainability permeates much of its activity:

- some research is primarily environmentally motivated: it aims to build understanding of our environment and its systems and processes to assist its protection and management for a range of objectives, including for its own sake, but also for the many functions and services it provides
- other research addresses the needs of economically-orientated sectors including energy and mining, manufacturing industry, agriculture, forestry, fishing and tourism (Attachment B indicates these)
- interactions occur to combine and balance environmental, economic and other social considerations.

This integrating capability has become an increasingly important aspect of CSIRO's activity and of great value to the nation. **However, research under the banner of sustainability is not a substitute for attention to developing understanding of the environment itself.**

Sustainability approaches have long been intensively explored by CSIRO in the rural sectors. The self-motivation of members of agricultural, forestry and related industries has been an important factor in the reasonable success so far achieved**.** CSIRO's rural sustainability focus continues to be important because there is much still to be done in agriculture and related industries – which place major, often damaging, demands on the functions, resources and services provided by our environment.

- **But there is also an increasing need for extending sustainability approaches in other sectors and contexts**. CSIRO is already doing this and sees a need to engage better the economic and environmental aspirations of Sectors such as energy, mining, and manufacturing to provide the integrated sustainability solutions required. The energy-environment interaction is one very important matter which has received attention within CSIRO recently, to good effect.



4. Australia's environment: responding to its nature and challenges

The degree to which many environment factors are unique to this ancient, long-isolated continent is a major reason to develop our own knowledge and understanding. European-based knowledge and practices brought here since 1778 have often proven unsuitable and have had to be redeveloped. **Science has played a major role in our ability to use our resource base: but that benefit has been accompanied by considerable costs.** Evidence typified by State of Environment reporting, and external views such as from the OECD, point to past and continuing damage and deterioration.

Environmental characteristics and the extent of damage are not canvassed here. The aim is to note that, for a long and fully rewarding existence here, Australians still have much to learn in identifying and responding wisely to our environment. Issues repeated in various contexts in this paper include:

- we must continue to identify key environment issues in detail and meet their knowledge needs
- strong attention should be paid to monitoring, assessing and reporting the success of individual or collective environmental programs and the overall state of Australia's environment
- science can and should link with economic, social and cultural considerations for more effective solutions. There is still insufficient knowledge in any of these matters and this inadequacy increases in terms of the broader and more integrated sets of approaches which are required
- investments in environmental repair based on unintegrated single elements of current knowledge – however large the sums invested appear to be - are in many cases unlikely to be sufficient
- adequate attention should be paid to proactive environmental management, not just to repair.

4.1 Sectoral or other viewpoints

There are numerous views of environmental and broader sustainability issues based on sectors of the economy or other specific viewpoints. Examples include planning by R&D Corporations, University groups, CRCs, Commonwealth and State departments/agencies, local governments; environment-related programs such as under the Natural Heritage Trust (eg, Bush/Land/Rivercare , National Land & Water Resources Audit,), umbrella bodies (eg, the NFF, and many others), environmental NGOs, companies (to small but growing extent in their environmental reporting). National strategies (eg, Rangelands, Greenhouse and - soon - Marine) have strong research implications and encompass ESD considerations, with varying adequacy. CSIRO participates in the development of strategies, engages with the bodies and programs mentioned, and takes account of all this in its sector-based planning.

To this must be added matters arising in many reports of Government and Parliamentary Committees, Ministerial Councils, and a host of advisory bodies at all levels of government including, in the Commonwealth sphere, the Prime Minister's Science, Engineering and Innovation Council.

Also relevant are matters arising in and from international bodies. These may be inter-governmental with the UN's Commission for Sustainable Development a very pertinent example. Often, they are science-based reflecting the international nature of environment problems and of the science input.

Agencies like CSIRO are active in these contexts and believe it important that science continue to be influenced by, and contribute to, domestic and international sectoral strategies, policies and programs.

4.2 An ounce of prevention

Response to, or remediation of, known problems gets much attention, including when looking for sustainable solutions. Much of the NHT has this flavour. Addressing problems that already exist is essential and should be properly tackled. But a stronger focus of investment should be on research to identify potential problems and seek solutions which can make them preventable or avoidable. As well, work is needed to anticipate and adapt where change is unavoidable. **Even in the absence of yet visible problems, research needs may exist.** What areas are in good shape, and what can we do to maintain this? What have we learned from past experiences to apply to new? What can we learn from elsewhere about potential problems (and responses)? What anticipatory monitoring do we need? What can we best address via international action? How can we manage multiple uses, and for diverse ends? **There is some danger that such elements of future management are not getting enough attention.**

5. Diversifying customers and stakeholders

Environmental research, and the wider sustainability set it serves, is of concern and benefit to all of society. Unlike areas where customers and their needs are concretely evident, ways often have to be found to translate from the general public interest in order to define specific projects. Government Departments provide a surrogate customer in many instances, particularly Environment Australia and also DPIE and DIST (now DAFF and DISR) but also several other Departments, agencies associated with Departments, and groupings such as the Australian Greenhouse Office.

Growth of environmental and sustainability awareness has increased the interests, sectors, industries and bodies demanding sustainable solutions. Increasingly, CSIRO works with other Commonwealth agencies, State bodies of many kinds, local government bodies and local groupings such as Landcare, universities, and industry. In consequence, funding pathways have also diversified, particularly for ESD applications. In sum, there is a large, growing and complex range of customers and funders for environment research and for its application in various sectors particularly towards sustainability.

5.1 International factors

Environmental issues are internationally ubiquitous and complex, although local factors are crucial in deciding responses. There are physical environmental connections (through air and oceans), transferred problems (movement of species, or wastes), very many science links, and agreements and structures. Some agreements are indirect in effect - such as environmental consequences of trade arrangements. Others bear directly on the environment, at levels ranging from major global conventions (climate, biodiversity, desertification, heritage) to the more specific (oil-spills, fisheries, forestry). CSIRO is active in the scientific links and forums and in supporting Australia's involvement in Conventions and agreements. **Australia's research agenda has to take strong account of the many extra-territorial signals: so, too, must our environmental and associated management.**

In a complementary sense, Australia's competence in ESD research can be utilised to assist other nations, particularly our neighbours, in understanding and responding to the importance of sustainable resource use (in the face often of strong short term pressures). Neighbours are also ESD stakeholders.

6. The place of research in meeting demand for ESD actions

Analyses of Australia's environment point to a powerful need for continuing research and for the intelligent, informed linking of current science-based understanding to observed problems. It is wrong to believe that sufficient understanding exists or that research needs are second order. Strategic research, and research to bring the best current research to bear on environment management, and sustainable practices, is a continuing need: but one under some threat.

This is not a plea for more research but a conclusion from analysis of Australia's environmental history, in terms of assessed practices of its long-standing indigenous inhabitants and impacts of settlers post-1788. History shows that sustainable use of our land requires careful observation and wise, information-driven management. It can profitably draw on lessons from earlier times, but has depended, and will continue to strongly depend, on the ability of scientists to develop understanding of our changing environment, thereby contributing to overcoming or preventing problems. (The fact that research benefits Australia's use of its natural resource base has been demonstrated in various ways, but is taken as given here). For management approaches which meet multiple goals - with ESD a paramount example - research is an important part of the organising framework. CSIRO's experience supports the view that, for best effect, research has to link to a range of social, cultural and economic considerations, fit with management needs and frameworks, and draw from both observation of local circumstance and knowledge of the world scene.

Science is one - and only one - ingredient of good environmental management which is the key to sustainability. For the best, most durable outcomes, research must be tightly bound with other elements, not treated as a stand-alone commodity or something likely to be readily obtainable "off the shelf".

6.1 Policy and other benefits of environment research

Environment R&D has strong public good characteristics (many participants, widely applicable, with substantial spillover effects). **Many reports affirm a strong case for major public investment in research underpinning uses of our environmental base. This is a prime area for CSIRO (see S7).**

Products, processes, tools and information are R&D outputs which tangibly benefit those managing environment-related activities and our environment and economy (Attachment D has examples). But research, including from CSIRO, has other rationales, outputs and beneficial outcomes, including:

- education and training
- raising public understanding and awareness
- contributing an important cultural value
- contributing to policy and program development.

Particularly important is the contribution which research insights can bring to public policy and program decisions- with advice to support private sector decisions also an increasingly significant outcome**. CSIRO has been very active in bringing science into policy processes**, international and national. Climate change developments through this decade are one powerful example. The positive and extensive contributions to the ESD process some 8 years ago another, and Attachment C gives a forestry example. **Scientific inputs to complex policy and program matters need to continue.**

Environmental problems are often complex, multi-dimensional, multi-causal and persistent. A good research base to address them needs scale, multi-disciplinarity, continuity, funding stability and reasonable independence from special pleading. Growth in sources of research, shifting and perhaps reduced private sector capability, small bodies with uncertain support, and funding stringency for all, puts pressure on long term and integrating research. This complex of factors heightens coordination needs. But, diversity has strengths and new collaborations provide opportunities and synergies.

7. CSIRO's place in the sustainability research spectrum

CSIRO has responsibilities for sustainability research, serving corporate goals to:

- develop ecologically sound management principles and practices for the use and conservation of Australia's natural resources
- achieve sustainable development in production systems and develop technologies to protect the environment

CSIRO environment role is widely endorsed. The Industry Commission, in 1995 concluded that:

> *"[environmental] research would generally not be done if it were left to private interests to finance . . . Such research has "public good" characteristics . . . This is CSIRO's niche . . . it lies between firms and universities in the area of research loosely described as 'strategic' . . ."*

Although environmental research is given particular emphasis in this submission, CSIRO's wide-ranging research for economic sectors has to be added to the mix, making CSIRO a research body of very particular relevance in Australia's quest for integrated sustainability solutions.

CSIRO frequently re-assesses its directions and, for, improved planning and user contact, now utilises "Sectors" focused on productive activities or environment elements. Its research Divisions and Sectors link in a matrix (see Attachment B). Four Sectors directly and primarily look at environment matters – Biodiversity; Climate & Atmosphere; Land & Water; and Marine. However, there is a very great deal of other environment-related R&D connected with production sectors, and will be more. In this way, CSIRO's planning framework is well suited to the integrations required to work towards ESD.

CSIRO is committed to interacting closely with all clients/stakeholders in setting its part of the environmental/sustainability research agenda. Advisory links and other ways this occurs include:

- overarching Government Workshops with a wide range of Departments every 12-18 months
- formal Liaison meetings with key Departments about twice yearly
- representation on many committees up to Ministerial level, including Commonwealth-State

- interactions with Parliamentary and party groups
- senior industry and government representation on CSIRO's 22 Sector Advisory Committees
- research and other partnerships with State groups and universities
- membership of CRC Boards (and management of some CRCs) and of other centres/groups
- membership of the Prime Minister's Science Engineering and Innovation Council (PMSEIC)
- support for NHT advisory committees and panels (perhaps underdeveloped and utilised as yet)
- membership of advisory bodies associated with some NHT programs
- membership of the Greenhouse Science Advisory Committee (GSAC) and other climate programs
- support for policy processes in government including through some inter-Departmental committees
- a myriad of day-to-day interactions with funders and users
- designated Key Account Managers for research funders such as RDCs, and other key groups
- Joint facility/program provision such as in Australian National Herbarium programs.

(Of these interactions with stakeholders / clients, there are probably none more frequent or extensive than with Environment Australia: but there are close links with a wide range of bodies).

The long and incomplete list shows the breadth of activity and two-way links between research and its users, with a growing interest at state levels and a need (mentioned later) to do more regionally. But these formal links and processes are well outweighed by constant informal contacts.

CSIRO plays many roles with many users and research performers, and in many combinations. But CSIRO's strategic and issue-directed focus, breadth, depth and scale, broad range of capabilities and national presence give it a special niche in broad-based and integrative work. This includes a strong sustainability focus, balancing economic and environmental forces across the wide range of Sectors for which CSIRO works. Because it is working intimately with a broad range of Sectors and their stakeholders, to contribute research which serves all their needs, including environmental, CSIRO provides sustainability solutions in a range of contexts unmatched in any other Australian enterprise. An example is the forestry case in Attachment C, with many others in fisheries and agriculture.

Radical new approaches by CSIRO. CSIRO is the biggest single performer of environment-related research. Yet, there has been considerable growth in the range of research performers (some of quite small scale) and a great deal of CSIRO's research is done in cooperative arrangements with others. Cooperative Research Centres are an obvious example, but even more of the collective and cooperative arrangements are outside CRCs. This could be termed a RADICAL approach - an acronym for Research and Development in Collaborations and Liaisons. The particular skills, values and advantages which each party can bring to the relationship have to be appreciated and respected. Such collaborations are obviously essential to the complex of issues which sustainability encompasses.

8. The wide range of research necessitates priority setting

Research across all environmental fields, linking to all uses of, and impacts on, environmental resources, and to social and economic factors, makes up an enormous set. The whole of Australia, rural and urban, has to be encompassed, with a strong global context too given the nature of many environmental issues. They often involve long timescales (eg, climate change). As noted, the scope and activity encompassed by the word "environment" is evolving at CSIRO well beyond a focus on the natural resource base. Environment-related work is spread throughout CSIRO, with attention now being given to ways to facilitate use of this broad capability in wider sustainability contexts. Given this complexity, project definition and priority setting can be extremely important.

Environmental research decisions need an eye on both environmental factors and ways they contribute to, and are impacted by, economic and other activities. They need to look at the interfaces and links between natural and physical research (and engineering) and social sciences and economics, as well as what these science-based insights tell us about, and how they relate to, social and economic issues. Effective planning and priority setting can help make sense of this complexity.

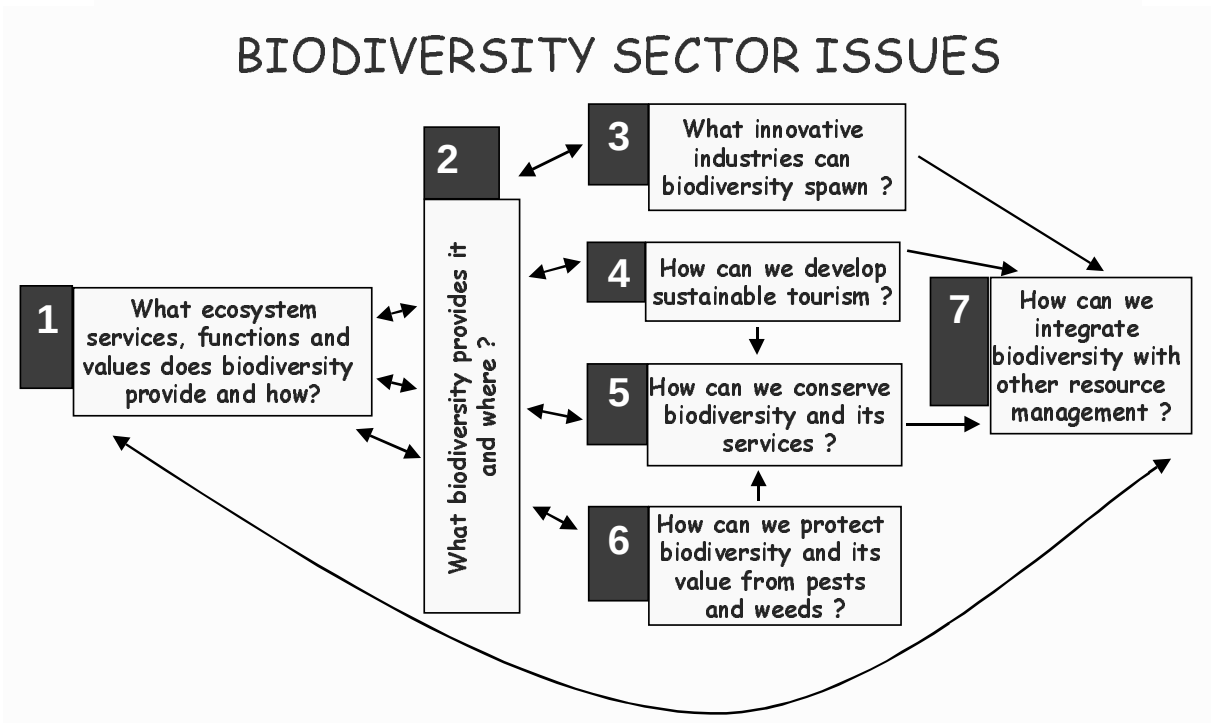
8.1.1 Sectoral examinations. One way to approach prioritisation is by sectoral or thematic subsets. Oceans Policy development and closely associated work on a national Marine Science & Technology Plan (both with considerable CSIRO involvement) are a soon-to-emerge example of a thorough sector-based approach to identifying issues and their corresponding research needs.

Another example of sector or theme based planning and priority setting is advisory and other arrangements for research in climate change - an issue with wide impacts and a growing complexity of policies, programs and institutions at all levels of government.

Sectors or the like are only one of many possible disaggregations of environmental research planning. Rural R&D Corporations are another model for helping judge the most worthwhile tasks and performers. The Land &Water Resources RDC has gone furthest in tackling direction and priority setting of a complex nature, but represents only part of the environment R&D set. There may well be a need for similar competitive fund planning arrangements in the marine area and in biodiversity.

8.1.2 Agency priority setting. Agency priority setting is essential in focussing on the most productive research. It is done in a many Commonwealth and State agencies and in CRCs. Due to the nature of CSIRO, the planning and priority setting it undertakes is the most wide-ranging. On the basis of 22 Sectors representing much of the economy, it applies well-tested methodology to assess the attractiveness to Australia, and research feasibility of proposals, allowing CSIRO's Executive to exercise sectoral and cross sectoral judgements. External input comes from Sector Advisory Committees and others and, corporately, the CSIRO Board has a range of responsibilities including to ensure that CSIRO has an effective, objective priority-setting process.

The following diagram of relationships between components (planning sub sets) of CSIRO's Biodiversity Sector shows one aspect of CSIRO's planning and, particularly, how sustainability considerations permeate, with environmental and economic considerations coming together to guide research directions. Here, consideration and understanding of the full range of services which biodiversity can provide helps prioritise work to develop essential knowledge and management measures suited to sustainability objectives in various sectors. (Tourism is specifically named because of the importance of biodiversity in attracting tourists; but very many sectors and activities benefit from biodiversity). This integrated approach, links also to relevant social and cultural considerations.



8.1.3 Cross-sectoral, cross-agency priority setting needs. Broad-based priority setting is difficult and sensitive. It was suggested in the past, and in the 1997 Stocker Review of Priority Matters, but not taken up. (It was raised in the *Inter-Sectoral Issues report of the Chairs of the ESD Working Groups* in Chapter 3.5, on *Research, Development and Information Issues*). The CSIRO methodology has helped in tackling broad issues, but could benefit from broad-level signals of preferred national directions, with one possibility being occasional peak level forums or mechanisms of overview. CSIRO gets some guidance of this nature from its Government Workshop with senior departmental officers.

Within Universities, and between, it is hard to discern patterns of planning and priority setting. It happens in some but, in others, activities seem based as much on the skills and interests of staff as on systematic assessment of needs: not surprisingly, national ESD goals are not often a major factor. Individual CRCs plan and set priorities, but the CRC system as a whole has few criteria to judge relative merits of work in one area versus another. Limitations apply also to funding bodies: they judge their own areas and priorities, but deal less readily with judgements between them, and on cross cutting environmental issues. Additional funding bodies or other ways to help ensure interaction and balance could be needed (see Section 8.1.1).

The NHT process offers one opportunity for a broad overview of national needs and opportunities (though NHT programs far from cover all environment issues). An overview could be undertaken as part of the evaluation which is required to occur. For identifying research needs, and correcting and enlightening the course of current research, delayed assessment and feedback is unfortunate.

8.1.4 Biogeographic regions. Another potential means of identifying and linking issues and setting research priorities, is use of biogeographic regions. Many environmental and sustainability issues relate to, and might be best tackled, regionally – so long as that region relates sensibly to the matters of concern. Regional approaches are supported in the NHT conceptual framework: but regional organising structures are not yet strong, and NHT progress has been somewhat minimal. This probably reflects inherent complexities, some conservatism associated with existing institutional and political arrangements, and mixed willingness to deal at this level. A few good and longstanding models have much hard gained experience to offer, including the Murray Darling Basin arrangements. Other areas might well benefit from similar overarching mechanisms, the Great Artesian Basin being such a case.

9. Research addressing key needs

CSIRO's research can appear to onlookers to cover a vast range of ideas and outlined in crowded and complex plans, and seemingly undifferentiated as to priority, since all work is supported by users. The following sub-Sections suggest a few unifying themes and sets to help distil some essential elements of the research in a sustainability context. Attachment D covers other examples of recent research.

9.1 Generic and integrative approaches

Australia has many skills directed to a host of specific research problems. This will always be needed, and is very well contributed to by the many tertiary sector research groups, and by CRCs for issues of greater scale. But more should be done to discern generic problems and solutions, a value-adding role on which CSIRO focuses much effort. Many environmental and sustainability problems are multi-faceted and need broad-based understanding and solutions. There is a need for holistic approaches to rural problems and those in our cities with their direct and indirect footprints on Australia and beyond. There needs to be an integrated approach covering economic, social and environmental priorities.

CSIRO has an unusual mix of breadth and depth in its environmental capabilities. It has worked to be good at large-scale integrative approaches (such as for catchments or regions, with the major Port Phillip Bay study as one example). This work is based on its internal capabilities or in conjunction with skills found elsewhere. CSIRO's own small in-house social science and economic capability and growing use of links with others provides the wide ranging approach and robust approaches which sustainability issues demand. In this way, CSIRO can add maximum value.

Broad-based approaches need to be adopted more widely. An assessment of grant applications, and other activities under the NHT process, could contribute by building a picture of generic problems and those which may benefit from integrative and other research.

9.1.1 Global Change. The functioning of Australia's economic and natural ecosystems is influenced strongly by large changes here and elsewhere, including in population, standards of living, land-use, CO2, ultraviolet radiation, and climate change: their sum is often termed global change.

- These interactive, pervasive changes and impacts have an underlying bearing on the sustainability of activities and require new, integrative approaches to assess likely impacts on things we value.
- Their over-arching nature requires they be dealt with at all levels from management units to policy, with stakeholder involvement critical in developing suitable adaptation options.
- Whilst global change is strongly linked to existing areas of research, such as on climate variability, it adds extra layers of complexity and uncertainty in the quest for sustainability.

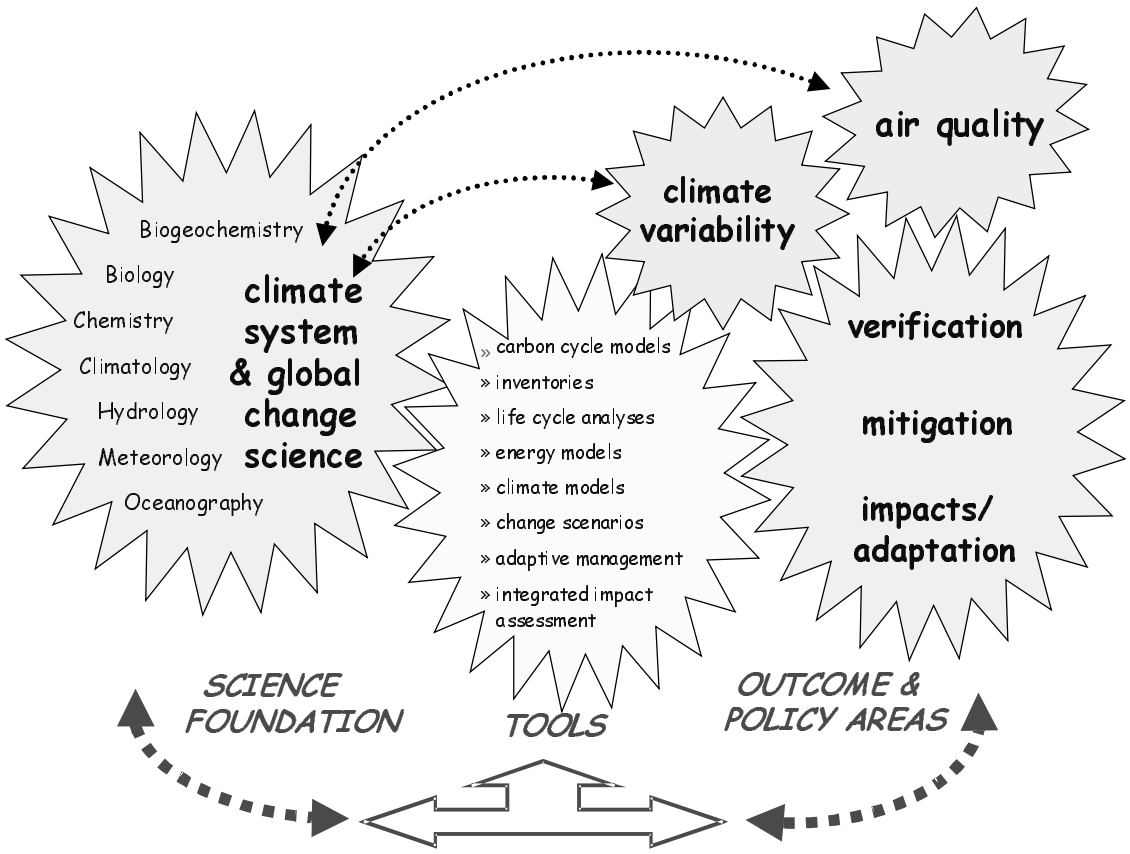
Underlying many problems is our limited ability to understand population-ecology-economy interactions. Methodological difficulties, and sensitivities raised by population issues, mean these major interconnections are under-explored. Making particular use of physical input-output modelling, CSIRO is working on sound approaches to examining these interactions and what they may tell us about possible the medium to longer term changes.

9.1.2 Climate Change. Impacts of climate change and variability, and possibilities for mitigation and adaptation are enduringly important, not the least for the sustainability of agricultural activities and the provision of services to cities. The climate area demonstrates the worth and power of international action, with global agreements a major driver. In this field, our scientific and technical infrastructure is stronger than many countries in our region. Its wise use is one way we can help our neighbours. Sensitivities in all these international activities necessitate a sound science base to our involvement.

Continuing support for the underlying science, which has had strong progress over the past decade, is needed, with more attention to adaptation, variability and prediction - which need the improving climate models as one driver. Arguably under-funded at Commonwealth levels, variability is getting attention in several States. Other needs include understanding of ENSO (the El Niño-Southern Oscillation), plus knowledge of Southern and Indian Ocean dynamics and the latter's link to Pacific Ocean systems, all of this being essential to understanding and prediction of weather and its variability. CSIRO researchers are also drawing strongly on economics to contribute carbon trading issues, a potentially powerful contributor to emissions reductions with complex environmental and economic implications. Amongst others, there may be impacts on forestry, an area of significant CSIRO effort.

A major cross-cutting need, arising from the Kyoto Protocol (under intense international scrutiny) is better understanding and measurement of sources of and sinks for greenhouse gases: this knowledge would have additional potential benefits to land use decisions. Climate Change matters also provide a strong reminder that estimation is required of levels of risk implicit in advice scientists give for policy and management purposes. Some pre-Kyoto inputs were founded on data with huge uncertainties: this does not make them less necessary or valuable, but stresses the need for scientists and policy makers to be clear about the status of advice.

The linking of science to users and uses, and of environmental and production factors, is illustrated in the following conceptual diagram of CSIRO's climate and atmosphere research. One of its major features for well over a decade has been powerful and effective links to policy and to global science.



9.1.3 Ozone layer. Ozone layer damage remains a matter to be watched. International action has been quite successful for fluorocarbons but, as a concomitant of burgeoning air transport, a strong potential for problems remains: estimates of up to 8 times more air traffic in mid-C20 than now may make airlines sustainable but perhaps at cost to global health. New damaging products are appearing.

9.1.4 A systems perspective. How do complex systems, be they a natural ecosystem (biophysical only), a farm (biophysical, sociological, economic), the Murray-Darling Basin or Australia (political biophysical, sociological, economic,), respond to disturbance. Each system has its own characteristic disturbance regime. Exceeding the bounds of this regime forces changes in the system. There can be both catastrophic change or opportunity, depending on whether managers are ready for it - able to anticipate alternative outcomes, and respond rapidly before the opportunity has passed.

There is a world-wide developing interest in the science of complex adaptive systems, and the implications of the behaviour of such systems for management. Conceiving of a system in mechanistic Newtonian terms leads to a quite different management response to conceiving of it as a self-organising, adaptive system. With the increasing trends of economic globalisation, climate change, land-use change and declining biodiversity (not the big hairy things, but the little things that run the world), we need to focus effort on disturbance regimes, and on what changes in these regimes will mean for the system concerned. If we in CSIRO don't take up the challenge of analysing our agro-ecological, socio-economic systems in the context of complex adaptive system dynamics, who will? (Based on a column by Brian Walker, CSIRO, 1998).

Science is contributing to a host of tools that assist sustainable management approaches including risk management, decision support systems (DSS), performance and other indicators, better visualisation techniques and other forms of enhanced communication, real-time information gathering and analysis, and better tools for funnelling and interpreting information and knowledge. While this submission does not elaborate, these sub-Sections, and the examples in Attachments give some of the flavour.
A major purpose in this overview listing is to demonstrate the necessity for research as one underpinning of management more attuned to, and capable of delivering, sustainable outcomes.

9.1.5 People are part of the problem and have to be a good part of the solution. Greater understanding is needed of the socio-economic context of decision making and of factors that will change the behaviour of resource users. This is an increasing feature of CSIRO's approach in, for example, CSIRO Divisions of Land & Water (social attitudes to water management strategies); Wildlife and Ecology (interaction of scientific and economic issues in management of rangelands and other areas; looking at broad economy-society-environment interactions); Tropical Agriculture (amongst other things, trying to give more opportunities for indigenous peoples to be brought into the equation: work with Land Councils is looking for better ways to engage all parties in balancing environment, culture and development factors); and Marine Research (also working with indigenous groups).

9.2 Bringing information to bear on issues

Environmental problems require collection, analysis and interpretation of large amounts of data, turning them into information and knowledge of value for policy, program, and management uses. This is especially true when trying to balance the mix of issues bearing upon sustainability.

9.2.1 Collecting data. This can involve, and benefit immeasurably from, remote sensing of various forms. The National Land & Water Resources Audit is a systematic linked data collection of great importance to sustainable land uses: its principles could well be extended – eg, to the marine zone. Data benchmarking is likely to be necessary in developing Australia's base 1990 position under the Kyoto climate change protocol and extensive data sets will be required in demonstrating compliance.

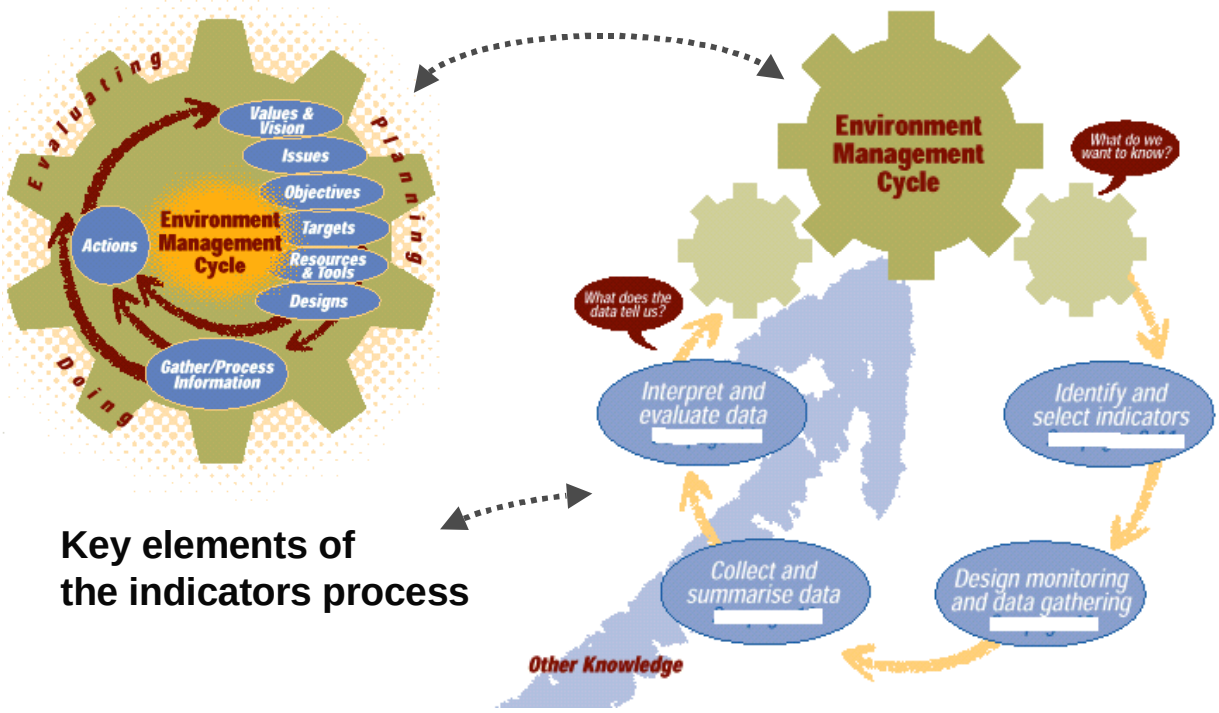
9.2.2 Summarising, analysing, evaluating and interpreting data. Complex environmental systems, and huge data collections, rely on sophisticated super-computing, modelling, mathematical and statistical techniques and risk analysis. CSIRO has such resources and skills.

9.2.3 Presentation. Visualisation, and decision support tools, are amongst those crucial in effective communication of the outcomes and understanding of science to users and the public. Interpretation and presentation of technical issues is important in many contexts, (eg, NHT programs). Weather and air quality provide examples of case studies of the value of presenting scientific issues in ways the public can understand and use to aid decisions. Together, the Bureau of Meteorology and CSIRO are developing better regional forecasting – specifically to help air management in the Sydney Olympics - but with wider on-going economic and social value. Meaningful representation of the forecasting data is needed, with an impression of probabilities, and links to responses which people might take.

9.2.4 Indicators. Physical, chemical. biological or socio-economic measures which best represent key elements of complex ecosystems or of environmental issues can be a powerful contributor to management processes, allowing description of environmental factors at some point, or as a trend. Better indicators for performance measurement at all levels of government and in the private sector are a continuing important need, the NHT programs being one focus of need. Better understanding of the benefits, and shortcomings of indicators, and how to use them integrally with the management cycle, is essential. A CSIRO initiative, supported by Environment Australia, has led recently to a booklet on the nature and sensible use of environmental indicators (*A guidebook to Environmental Indicators*, CSIRO, 1998). Sustainability indicators add a further layer of complexity: much is already happening (particularly in agriculture and forestry) but more is required.

Indicators are one means by which science can contribute to more effective, programs and policies, and wider management, aimed at more sustainable outcomes. Contribution to informed policy debate and better programs is an extremely important activity of CSIRO in fulfilling its national charter.

The essential link of indicators to management, detailed in CSIRO's booklet (above), is shown below.



9.3 Bio-geographic based sustainability issues areas

As earlier noted, some issues are profitably tackled on the basis of regions of varying size, such as:

9.3.1 Catchments. Catchment approaches can be a powerful integrating factor. They may link the inland and the coast, rural and urban water, and related issues, cutting across jurisdictional boundaries. Dealing satisfactorily with catchment management requires bringing together natural and physical factors with social and economic ones, and sound science with management. CSIRO has skills in many aspects of catchment approaches and is working with others to develop a major demonstration of best practice, an integrated approach to sustainable land management in the Murray-Darling Basin.

9.3.2 EEZ-Marine zone. Our 11 million square kilometres of EEZ has many unknowns. The Government's Marine S&T Plan process is now defining key research needs, and the Oceans Policy process is likely to highlight the need for, and difficulties in achieving, sound multi-use management. Marine biodiversity is a relatively neglected field, as is broader monitoring of ocean health. CSIRO has recognised the needs associated with declaration of the EEZ, and the relative ignorance of the marine zone, by increasing investment within its Marine Sector. More is needed nationally, perhaps through an integrated cross-portfolio approach involving all relevant Departments and agencies.

9.3.3 Coastal zone impacts. Although recognised as important (eg, in State of Environment lists of problem areas), impacts in the coastal zone get inadequate research investment. Given the complexity of uses and jurisdictions in the zone, major work across a range of sciences and social and economic fields is essential. Efforts to improve research have been relatively modest, and of inadequate impact. But, in one example of on-going R&D, CSIRO is increasingly working with State water and sewage agencies to develop the modelling and other understanding for systems impacting on our coasts.

9.3.4 Rangelands and agricultural areas. Australia's arid and semi-arid zones have had much inquiry. The national rangelands strategy (like others such as biodiversity, wetlands) is one guide to problems and research needs. CSIRO is focusing its work to achieve greater synergies and impacts in helping reconstruct Australia's rural "heartlands". The MDB project (above) is relevant, with many other studies possible in extensive and often "high use" zones where biodiversity conservation is critical.

9.4 Rebuilding the environment

Earlier, we highlighted the need, if Australia is to be a more truly sustainable society, to give greater attention to better, more forward-looking management. Nevertheless, recovery of areas degraded by past use (and natural causes) is crucial. Solutions are sought in matters from degraded arid lands to catchments, paddocks and mine-sites. Revegetation, rehabilitation, and remediation are some of the interlinked concepts. Strongly important is prevention of loss of native vegetation and re-vegetation for such reasons as aesthetics, soil loss control, as a greenhouse sink, maintenance of biodiversity habitat, and for economic purposes - particularly, but not solely, through forestry.

9.4.1 Soil problems including Salinity and Acid Soils. Some 12m hectares may be affected by salinisation by mid next century - with attendant impact on rivers, wetlands, roads and other infrastructure, remnant vegetation, biodiversity, and so on. This problem is prominent in the Murray-Darling Basin, but is far more widespread. Time scales for reaction are short and shortening.

Work in recent years, with major CSIRO inputs, has shed much light on the growing extent of acid soils and on physical and chemical processes involved. **Beyond the evident and widespread effects of salinisation and acidification, are many other soil matters to address, including soil fauna, structural decline, fertility loss and the contamination and remediation needs noted above. Soils related matters are a prominent example of the need for broad-based approaches.**

9.4.2 Minesite rehabilitation. Using soil, biodiversity and other expertise, CSIRO with the support of industry and links to other research groups, is active with in minesite rehabilitation and, more proactively, in advising on assessment and management of new mine areas.

9.5 Some emerging areas in which CSIRO has instituted projects

Through a competitive process in 1997, involving its Sector Advisory Committees, CSIRO's Executive funded to June 2000 a series of projects seen as opportunities to showcase skills and address significant problems. Those relating directly to sustainability include:

9.5.1 Sustainable energy.. This project will demonstrate a new concept for electricity production at 70% thermal efficiency (twice most coal-fired power) capturing carbon dioxide emissions for disposal, storage or use. It will be a solar-fossil fuel hybrid, utilising fuel cells or micro-turbines. CSIRO is building a broader contribution to sustainable energy futures. Other recent CSIRO work has located optimum sites for wind energy installations (Attachment D has more on all these examples).

9.5.2 Low Emission Transportation Technologies. The project will demonstrate an integrated group of hybrid-electric car technologies designed to improve fuel efficiency and reduce greenhouse and noxious gas emissions. Longer-term additions may include new magnesium alloys for lighter components and fuel cells - an alternative, environmentally-preferable energy system.

9.5.3 Novel Technologies for Feral Animal Control. This project aims to develop a repressible sterility technology to prevent feral animal establishment or control existing populations. The approach is difficult technically and will requiring regulatory approval to bring into practice, but it has great potential as a robust long term pest management tool.

9.5.4 Sustainable Urban Water Systems. CSIRO is taking a lead, with industry and agencies, to stimulate radical rethink of design, equipment and management of urban water systems to allow, for example, supply of water of quality suited to varying uses, and reduce demand for new storages.

9.6 Infrastructure/capability needs which flow from research needs

Generic and integrative approaches to major environmental and sustainability problems require maintenance of significant investment in many areas, amongst which are:

- Supercomputing
- Modelling
- Continuing access to, and ability to use, remote sensing
- Research vessels
- Automated data collection
- Risk management approaches
- Capabilities for ever-finer particle detection and analysis
- Remediation Technologies.

9.6.1 Taxonomy and Systematics. These underpin understanding of our flora and fauna for environmental, social and cultural reasons and for enhanced economic uses, such as through bio-prospecting – looking for economically valuable elements in species. Inadequate investment is being made in these areas. There is a need for more taxonomists and development of new approaches.

9.6.2 Bioinformatics. CSIRO is increasing its investment to provide secure, single point access to databases of genomic and biodiversity information. This will allow rapid integration of information at levels from gene to ecosystem as well as improved data analysis, visualisation tools and training. In this, CSIRO is very actively linking to a number of others world-wide through an initiative under the OECD's Megascience Forum program which is hoped to lead to a global biodiversity information facility in which Australia might well have a significant role.

9.6.3 Other. As is evident from much of the preceding text, there is a range of other skill/capability needs which arise from the nature of ESD research. In CSIRO's case, this especially includes the broad-based and integrative role which CSIRO sees as both essential to effective solutions and an area in which it can offer particular comparative advantages. The skills in question are not only disciplinary based but extend to integrative capabilities, skills which tend to be acquired in post-Doctoral and other experience. Relevant capabilities include in ecology, genetics, biometrics, remote sensing, modelling of different kinds, and risk management - but also many others. Other capabilities or competencies of particular relevance include an ability to work in or contribute effectively to teams, linking closely to users, and being able to interface with economists and social scientists.

10. Key drivers of Sustainability Research into the 21st Century

In setting its environmental research agenda, including applications towards sustainability, CSIRO takes account of many Australian and global issues. A driving factor, at international, national and local levels, is the ESD imperative - harmonising social, economic and ecological factors over a long period. CSIRO deals with the research needs both of production sectors, and of environmental resources, and so addresses issues of sustainability daily. All its work takes account of the following:

10.1 Internationalisation

- **New trade regimes** facilitate company operation and goods and services movement across boundaries. Interlocking of national economies adds complexity and pressure to domestic environmental and economic standards. Environmental implications of trade regimes are slowly being teased out in world organisations: ownership of resource-based. intellectual property can be one important factor.
- **Environmental quality** is an important source of trade differentiation and advantage; competitiveness requirements will be a driver of environmental management; and standards will have to be transparent and internationally accountable.
- **Spread of exotic pests and diseases** is accelerated by trade and travel and must be managed to ensure we can maintain our environmental standards.
- **Global security** concerns have environmental implications: **Eco-terrorism** (eg, against water) is a possibility with both national and global motivations.
- **Growing international travel** is one cause of spreading environmental impacts due to the movement of potential pest organisms, and pressures on visited sites. At the same time, environmental quality is an increasingly powerful factor motivating tourists.
- **Privatisation,** often involving internationally operating companies, affects provision of utilities (power, communication water): their domestic R&D support capability is sometimes reduced.
- **"Competitive Neutrality"** can involve a market-based realignment of past public sector provision of goods and services with implications for research providers.
- **International environmental agreements** exist in many fields such as climate change, marine biodiversity, heritage,: the Kyoto protocol shows the powerful domestic influence agreements may have, an influence which will multiply if carbon trading becomes a reality.
- **International environment structures** for coordination and leadership are significant (eg, the UN's Environment Program UNEP; and its Commission for Sustainable Development, CSD).
- **Global inequalities** exist in access to, and quality of, environmental resources. The less developed face strong pressures, both internal and external (including through population growth, economic development and trade), on their natural resource base. The effects reach all corners, but Australia - in Asia and Oceania - has to deal with them up close.

Population growth, lifestyles, and demands for sustainability

- **Food, shelter and resource requirements** are strongly linked to the product of population size and economic status/lifestyles: Australia's domestic population continues to grow (mainly in major cities), providing one increasing pressure on resources.
- **Rising living standards** put demands on resources, but also provide income for the better environmental management which affluent societies demand. The **interaction of factors** is complex and only through sensitive and responsible management is affluence guaranteed to benefit the environment.
- **Human health, and ecological health**, are both important forces for environmental action.
- **Equity and access** are significant and sensitive aspects of population and environment-linked matters: the Kyoto Climate Protocol and issues of access to biological resources illustrate this.
- Achieving **ecologically sustainable development** must be seen globally, not just nationally: diminishing resources and increased demands elsewhere multiply pressure on our resources.
- **Sustainability** concepts need to be transformed into a better practical realisation of the balancing of growing pressures on our environment with the high valuation given to its quality.

New technologies and understanding

- **Developing technologies** (eg, remote sensing) are leading to better environment management possibilities.
- The so-called **"knowledge revolution"** where computing advances are leading to enormous power gains in creating, storing, analysing, distributing and applying knowledge.
  (eg, Bio-informatics - covering genes to ecosystems).
- **Gene technologies** affect many matters including safety, conservation obligations, pressure for access to genetic resources, potential modification of production systems and of ecosystems.
- **Advanced data handling, computing and communication** greatly assist management, monitoring and impact assessment. Networked, they facilitate approaches from regional to global and help community understanding and participation, vital in environmental issues.
- **Industries based on environment technologies** are growing, one of many technology facilitated changes to the nature of companies and industry structures. Knowledge-based services and environmental management technology companies are becoming more important.
- **Multi-disciplinary research** is often the key for complex environment issues: it benefits from scale and teamwork. But disciplinary depth continues to be a major driver of science.

Demands for planning and accountability

- **Planning, priority setting and accounting** for outcomes are crucial in a time of strongly competing demands. Sources of priority setting and research commissioning have burgeoned in number if not fund levels. This is one factor contributing to a greater complexity of resource management and contractual relationships with concomitant time/cost overheads.
- **Corporate governance** increasingly includes an environmental obligation.
- **Community demands** for better environmental standards are reflected in a growing network of environmental regulation with accompanying monitoring and reporting.
- **Industry accreditation** via ISO14000, and environmental reporting, are becoming common.
- **Ethics and values** are an important factor in environment and many other fields.
- **Openness and peer review** sustain excellent research. The public good nature of environment R&D requires very strong accountability, with particular attention to ensuring balanced objectivity in cases where there is a significant proprietary element in the research.

10.2 Changing research structures

- **Enterprises have become more involved** in research-based means to fulfil their environmental obligations, encouraged by heightened environmental consciousness (theirs, and community), backed by the need to meet mandated standards. Benchmarking and indicators are required.
- **Private sector R&D skills** have grown in some cases, but changing ownership has at times diminished, or relocated offshore the pre-existing in-house R&D capabilities.
- **The global networks of science** have continued to expand, both in terms of science-based associations and institutions, and linked in various ways to international bodies and agreements.
- The **range of research performers**, public and private, has increased, some with substantial research capacity, others more focused on consultancy and research re-packaging.
- **Diversification** has created a complex variety of **collaborative arrangements** involving contractual and sub-contractual relationships between multiple agencies, and increased complexities where a mix of public good and private benefit research is involved as is often the case under the broad ESD banner.

10.2.1.1 CSIRO Divisional Membership of Alliance and Sector Groupings

*

DIVISIONS / SECTORS	Environment & Natural Resources				Agribusiness						Information Technology, Infrastructure & Services					Manufacturing			Minerals & Energy			
	Biodiversity	Climate & Atmosphere	Land & Water	Marine	Field Crops	Food Processing	Forestry, Wood & Paper Industries	Horticulture	Meat, Dairy & Aquaculture	Textiles, Clothing & Footwear	IT & Telecommunications	Built Environment	Measurement Standards	Radio Astronomy	Services	Chemicals & Plastics	Integrated Manufactured Products	Pharmaceuticals & Human Health	Energy	Mineral Exploration & Mining	Mineral Processing & Metal Production	Petroleum
11.																						
Atmospheric Research		●																				●
Entomology	●	●	●		●		●	●	●			●				●		●				
Forestry & Forest Products	●	●	●				●					●				●						
Land & Water	●	●	●	●	●		●	●	●	●		●								●	●	●
Marine Research	●	●		●					●													●
Wildlife & Ecology	●	●	●	●	●		●		●	●					●					●		
Plant Industry	●	●			●	●	●	●	●	●						●	●					
Animal Health						●			●	●							●					
Animal Production		●		●					●	●												
Food Science Australia					●	●		●	●							●	●					
Human Nutrition					●	●			●									●				
Tropical Agriculture	●	●	●	●	●				●	●												
Wool Technology										●												
Australian Telescope National Facility														●								
Manufacturing Science & Technology						●						●			●	●	●			●	●	
Mathematical & Information Sciences	●	●	●	●	●	●	●	●	●	●	●	●		●	●		●	●		●	●	●
Molecular Science												●				●	●	●				●
Telecommunications & Industrial		●								●	●	●	●		●	●	●			●		●
Building Construction & Engineering												●				●	●				●	
Energy Technology								●	●	●										●	●	
Exploration & Mining										●										●	●	●
Minerals																					●	●
Petroleum Resources																				●		●

- **Divisions** are the research-performing "business units" of CSIRO: they are line management structures
- **Sectors** are a liaison and planning device, helping CSIRO to interact with, and understand the nature and needs of, its many clients and stakeholders
- **Alliances** are groups meeting from time to time to assist activities of Sectors with strong common interests

A case study: Science helping to resolve Forest Policy

1. Opportunity and Objectives

Following the 1992 Rio Earth Summit, the importance of policy and practices related to sustainable forest management increased markedly. Commonwealth and State Governments and the forest industry have worked to develop and implement policy consistent with international commitments and the National Forest Policy Statement. Key activities have been:

- the Regional Forest Agreement process (costing about $200 M) to establish the balance between conservation and wood production in native forests, and to specify processes and practices to achieve ecologically sustainable forest management on all tenures.
- review and updating of Codes of Forest Practice, and
- the application of Criteria and Indicators to improve forest management.

As part of these processes, CSIRO was asked to contribute high-level scientific panels/advisory groups and, as a consultant to Commonwealth or State governments, to conduct analysis and syntheses.

3. Activities and Outcomes

A number of high-level activities were conducted between 1995 and 1998 by multidisciplinary teams of scientists from CSIRO forestry and wildlife Divisions, and sometimes universities. CSIRO contributed advice often on short time lines and in an environment of conflicting views. A key challenge was to combine scientific integrity with the need for urgent practical outcomes.

The following broad categories of activity have collectively raised national management standards:

- Review of State Codes of Forest Practice (and related removal of export controls on unprocessed plantation wood). Revision of Codes based on the CSIRO reviews have improved their effectiveness by incorporation of contemporary scientific concepts. This work has also contributed to achieving more uniform national standards.
- Assessing the adequacy of forest conservation strategies (classification and reservation of old-growth forest, contribution of linear reserves, off-reserve conservation management) forming part of the Regional Forest Agreement (RFA) process. CSIRO has effectively argued for incorporation of modern scientific principles into conservation strategies.
- Providing major contributions to pioneering the conceptual framework and methods for assessing ecologically sustainable forest management which was fundamental to the RFA process in East Gippsland, Tasmania and NSW. CSIRO chaired the Expert Working Group conducting the NSW assessment– possibly the most difficult: it involved the largest State; complex legislation and operational arrangements; multiple forest management and regulation agencies; on-going reforms and a tense political environment. The assessments recommended major forest management improvements, and provided guidance acknowledged as invaluable to more effective procedures.
- Contributing to the Montreal Process Implementation Group for Australia. This high-level group is guiding development and adoption of Criteria and Indicators for sustainable management of Australian forests consistent with the intent of those developed internationally. CSIRO has had a key role in strengthening the scientific basis of indicators and associated monitoring protocols.
- Provision of advice on greenhouse biology via the Agriculture and Forestry Working Group contributing to the National Greenhouse Response strategy; inputs to the National Greenhouse Gas Inventory; and in discussions with staff of Commonwealth Government Departments. CSIRO Forestry and Forest Products has also contributed to the Intergovernmental Panel on Climate Change assessment for forests, covering impacts, adaptations and mitigation.

4. Conclusion

Collectively, CSIRO contributions have assisted Governments and the broader forest community to develop and implement effective policies and practices to enhance sustainable forest management in Australia. The high scientific standing of CSIRO officers, and their capacity to contribute to practical outcomes, has strengthened the credibility of decisions amongst all stakeholders.

Attachment D

Selected examples of recent CSIRO research related to ESD

The following list of recent research is classified in accord with the CSIRO Sector in which the work was planned, but often it applies to several Sectors. It is not a complete list, nor is it ranked, but it illustrates the breadth of CSIRO's continuing contribution to ESD.

BIODIVERSITY SECTOR

Contributions to better management

- Proposals to use management agreements to conserve native vegetation outside reserves have had strong CSIRO input.
- CSIRO has located new populations of the endangered golden sun moth, information important for management and conservation.
- CSIRO's finding of substantial variation in effectiveness among *Rhizobium* isolates from *Acacia* and other native legumes is significant for farm revegetation, especially in acid soils where rhizobia populations may not survive for long.
- In Western Australia's wheatbelt, the Dongolockings are remnants of native vegetation too small to indefinitely maintain plants and animals dependent on them for protection against extinction, and faced with creeping salinity from over-clearing. Completed with local farmers and State agencies, CSIRO's revegetation plan should provide sufficient habitat for species at risk and mitigate salinity. It rests on local knowledge of the size of habitat patches allowing vulnerable species to persist.
- In Sarawak, CSIRO marine biological research, management advice and re-seeding of estuaries, has helped save an economically and traditionally important fish, the Terubok, from likely extinction.
- Growers are adopting CSIRO recommendations on best practice management of mouse populations in Victoria's Wimmera and Mallee districts.
- CSIRO scientists have made extensive contribution to our understanding of the role of fire in the Australian landscape particularly the way it influences biodiversity.

Combating pests and diseases by biological means

- In work jointly funded with port and ballast water authorities CSIRO completed an Australia-wide port survey for infestation patterns of exotic marine pests, helping build management options to minimise invasion. CSIRO is developing comprehensive risk-analysis for ship-based sources of infection and looking for Japanese and European parasites that may be safe biological control agents.
- CSIRO has helped develop and monitor rabbit calicivirus disease (RCD), one tool in the fight against rabbits, an environmentally and economically costly pest.
- Bitou bush is a major environmental weed, smothering native flora. If its seed supply can be cut, destruction by other means will be enhanced and native habitats better rehabilitate. A fly whose larvae destroy 60% of the seed, is establishing rapidly along the east coast since release by CSIRO.
- CSIRO has coordinated a survey of records of exotic species, revealing that some 200 species have invaded Australia in the last 25 years, information crucial for strategies to strengthen our quarantine protection and reduce future weed problems.

Indicators of success

- For a mining consortium, CSIRO has developed and field tested indicators of minesite ecosystem rehabilitation success. The approach rests on Ecosystem Function Analysis. The package of field procedures includes a landscape function analysis, assessing control of vital site resources such as water, organic matter and nutrients; a vegetation development analysis of species composition and growth characteristics; and habitat complexity, assessing habitat quality for vertebrate fauna.

- CSIRO reported on strategies and indicators for monitoring the state of our marine environment, with emphasis on the high use coastal zone, and on biological diversity, linked to the National Strategy for Conservation of Australia's Biological Diversity.

Models to look to the past and the future

- A dynamic rainforest model uses terrain, geology, and climate inputs to predict distribution of 15 forest types in the wet tropics. It will help estimate their pre-clearing distribution, and effects of climate change, knowledge critical to effective conservation plans for the Wet Tropics World Heritage Area and wider region.
- CSIRO's *OzEcco* model tests alternative future scenarios. It is the first substantial integrated representation of Australia's physical and economic systems, necessary for exploring how sustainability (physical) goals might be achieved through planning and policy (economic) tools, and how economic decisions impact on sustainability.
- Cooperatively developed CSIRO models combine koala diet and eucalypt data to predict koala distribution in northern NSW.

Books, guides, checklists and catalogues.

- CSIRO has published new editions of its handbooks on plant systematics research and weeds, volumes which contribute significantly to scientific effort in these areas.
- CSIRO's EUCLID is a comprehensive CD-ROM allowing users to identify eucalypt species, quickly and simply, from leaves, flowers or gum nuts. This landmark system has been praised for providing enormous amounts of taxonomic information in a form immediately useful to a wide audience.
- CSIRO's major plant taxonomic works are a vital base for ecological and conservation studies. CSIRO is developing interactive keys to help non-taxonomists identifying plant material, a significant contribution to the effort to document, understand and conserve Australia's biodiversity.
- CSIRO has published a unifying reference list of Australian fauna with conservation status for people who work with or publish on our amphibians, reptiles, birds and mammals. It provides accurate names and up-to-date taxonomy for all species protected by legislation, the first time this has been collated and published.
- Major recent inventories of Australian mites provide indispensable information for quarantine officers, ecologists, and in pest control, agriculture, human and animal health, parasitology, and soil biology. Mites aid plant litter decomposition, soil formation and nutrient cycling and have capacity as indicators of soil health.
- From collaborative remote sensing with Japan, a CSIRO CD-ROM introduces users to central Australia's vast environment, and links to the research literature that underpin our understandings.

CLIMATE AND ATMOSPHERE SECTOR

Probing El Niño

By examining long-term climatic records, CSIRO is helping understand El Niño cycles. In addition to the well-known dominant 2-7 year cycle, CSIRO has identified 11-13 and 15-20 year climatic fluctuations. This observation, and modelling, suggest global warming this century is unlikely, to date, to have influenced El Niño. For Environment Australia, CSIRO modelled likely impacts during the next 150 years, concluding that El Niño and its opposite La Niña will continue, possibly with greater frequency than now. Such climate simulations also add information on natural variability.

Enhanced livestock production and greenhouse gases

Methane is a major component of greenhouse gases derived from agriculture and most of it stems from organisms which produce methane in sheep and cattle rumen. A CSIRO developed vaccine can reduce methane production by 80 per cent, and improve livestock productivity. It is now being developed towards commercial release.

Scientists prepare to reap the wind

A world lead in a promising renewable energy source - wind harvesting - stems from a CSIRO technique which pinpoints areas of richest potential in terms of landscape and prevailing winds. Wind prospecting blends fluid dynamics, topography, meteorology, demography, modelling, and statistics with scores of towers measuring wind speed and turbulence. With supplier Pacific Power, CSIRO identified a major wind 'hot spot' near Crookwell, now becoming Australia's largest and first grid-connected wind farm. With a good wind, 8 turbines will pump out 5 megawatts, the average demand of at least 3,500 homes, cutting greenhouse-gas emissions by 8,000 tonnes per year.

Greenhouse impact on plants

- CSIRO has shown that increased carbon dioxide in the air makes plants grow faster and cope better with drought and salinity. A doubling could lift growth rates 30-40%, under well-watered conditions. Scientists are working to capitalise on such potential benefits of greenhouse warming while assessing negative impacts that climatic changes may have on the environment and agriculture.
- Better prediction of the impacts on forests from the 'fertilising' effect of higher carbon dioxide, and temperature rises and rainfall changes, comes from a study by CSIRO and the University of NSW. A new suite of three linked models covers forest growth and long-term soil responses on time-scales from days to rotations. They assist forest planning and management by indicating the effects of climate change on eucalyptsand pines in different parts of Australia. They also indicate the potential of forests and the soil to store carbon, cutting atmospheric levels.

Insects and climate change

- CSIRO produced integrated climate impact assessments for Queensland fruit fly, light brown apple moth and insect-related dieback of rural woodlands.
- Climate variability information provided an ENSO (El Niño Southern Oscillation)-based warning of the need to vaccinate Queensland cattle against tick fevers. Above -average temperatures in early 1998 resulted in disease outbreaks in unvaccinated cattle, confirming the forecast, but emphasising the need for industry to respond.
- CSIRO is leading global research on global change and pests, diseases and weeds through the International Geosphere-Biosphere Program-Global Change and Terrestrial Ecosystems (IGBP-GCTE). In a Kenya workshop, global agricultural, environmental and medical communities compared impact assessment approaches.

Oceans and climate change

- The North Pacific was thought to be an almost motionless basin. But CSIRO has discovered large-scale deeply circulating currents (gyres), an input to understanding better the deep ocean circulation, a critical element in simulating climate change.
- CSIRO completed a global bio-geochemical model to simulate marine carbon cycling, better understanding of which is essential for attempts to monitor carbon dioxide emissions from terrestrial sources. The model was applied to quantify ocean absorption of carbon dioxide in the present climate and predict its change in future Greenhouse scenarios. It can also enhance understanding of marine ecosystems.
- A CSIRO discovery has increased our understanding of how the oceans delay the build-up of the Greenhouse effect. The work shows that the Antarctic coast south of Tasmania is a major source of dense water - Antarctic Bottom Water - which sinks and takes atmospheric carbon dioxide and oxygen into the deep ocean.
- CSIRO marine and atmospheric scientists are working together to improve and link models that predict how climate varies across seasons. Observations from the central Pacific were fed into the ocean model and have significantly improved its ability to predict sea surface temperature anomalies over a six month period.

Understanding and improving air quality

- As part of long-running collaboration between CSIRO, Japan's Meteorological Research Institute and the Indonesian Bureau of Meteorology and Geophysics, scientists examined the atmosphere over northern Australia during the annual burning-off period, determining the composition and likely origin of particles, helping our understanding of haze sources and impacts in Australia and Asia.
- In response to severe air problems in South-East Asia from forest fires, the measurement campaign expanded to study chemistry and smoke dispersion in Indonesia. Atmospheric particles were found to differ considerably in composition from those over Australia, contributing to visibility reduction problems in the region.
- For the Hong Kong Environmental Protection Department, CSIRO's air quality expertise is building a state of the art modelling package to evaluate emission control and planning scenarios. The work also involves Victoria's Environmental Protection Authority and Australian and overseas collaborators. CSIRO is modelling regional and local wind and temperature fields for a three-dimensional air chemistry model which predicts pollutant concentrations, including aerosols and ozone. A field study of vehicle pollutants in Hong Kong will contribute to the emissions inventory.
- CSIRO airborne measurement and estimation of the total of key pollutants can test the accuracy of the developing Hong Kong emissions inventory. The measurements also provide detailed wind data to test the validity of the modelled wind fields and generate detailed air pollution data to test the air quality model.

LAND AND WATER SECTOR

Land monitor project

A collaborative project to assist land management in 24 million hectares of agricultural, forest and remnant vegetation areas in Western Australia uses CSIRO techniques for processing satellite images. It will map and monitor changes in woody vegetation, revegetation and salt-affected land, and predict areas at risk. Management products at paddock, farm and catchment scales to suit customer needs, will include enhanced imagery, land cover, salinity and vegetation maps, and spectral/temporal statistics.

Tools evaluate sugarcane land use practices

- A CSIRO decision-support system to assist users evaluate changes in resource use in the Herbert River catchment is available on-line for testing and use. CSIRO analysed changes in wetland dynamics in two major sugar areas. It also analysed stakeholders' land-use planning information needs as a preliminary to a study into factors influencing land use practices and resources use in the sugar industry. The worth of existing knowledge sources was evaluated using innovative methodologies not previously used in a sugar industry context. Economic and social profiles of the two catchments, trends in resource use and employment and income implications were documented. A prototype economic-environmental model of the sugar industry able to analyse land use change scenarios will add to the decision system.
- A spatial analysis of issues associated with cane land allocation in the lower Herbert River catchment completes an evaluation of social equity and environmental impact. Results will feed into wider examination of the cane land allocation process to develop improved policy and planning. There were contrasting stakeholder perspectives on the allocation process and significant areas where industry, government and community aspirations for resource use are in conflict.

Assuring groundwater supply in the Clare Valley

Driven by concerns that growers may be extracting groundwater faster than it is being replaced, CSIRO is working with South Australian groups to assist the expanding wine industry achieve sustainable water management. A field experiment in the Clare Valley is measuring how quickly water is flowing through

cracks in the underground rock, and how fast it is being replenished. The results will help chart water volumes through the fractured rock aquifers which underlie about 40 per cent of Australia.

Water and sediment quality

CSIRO was a major player in a revision to water quality guidelines used by all Australia's regulatory bodies. They will now be risk-based, allow consideration of metal speciation instead of total metal levels, and reflect new sediment understanding. CSIRO work has helped understanding of factors controlling metal bioavailability in sediments and has shown speciation's influence on bioavailability.

Advantages of 'precision farming'

'Precision agriculture' uses satellites and associated techniques to improve paddock management and increase profits. A CSIRO project confirmed that applying only as much fertiliser as the paddock needs, is one key to environment benefits, and profit. Farmers also need apply only as much herbicide or insecticide as necessary, keeping environmental impacts to a minimum.

Better coordination for regional planning

CSIRO and the Central Highlands Development Corporation in Queensland are partners in a Regional Planning Secretariat established to service and coordinate input from a range of groups. It has facilitated key regional strategies on Pest Management, Vegetation Protection, and Transport Infrastructure Coordination; assisted formation of a Central Highlands Environment Information Network; and greatly improved coordination among stakeholders including local government, development organisations, Aboriginal and conservation groups and State agencies.

Ways to fight blue-green algae

- CSIRO has discovered a cheap, naturally-occurring, clay-like compound which, after treatment, can be spread across river or lake beds, locking up enough essential phosphorus to prevent algal blooms, lowering the risk of toxic poisons entering water supplies and environment. If sprinkled into a water body in which a bloom has developed, it will strip out enough phosphorus to starve the algae.
- With State and local groups, CSIRO is stocking two Queensland dams with predatory native fish to test a way of preventing outbreaks of toxic algae. Large fish feed upon small fish and these eat small water animals (zooplankton) which eat blue-green algae. More big fish should mean fewer small fish and, in turn, more zooplankton and less algae. If this first test here of a Northern Hemisphere technique is successful, it could translate into improved fish catches for anglers and enormous savings for water managers, primary producers and government agencies.

Making cents of sewage

- CSIRO has developed electro-dewatering to enhance performance of sewage plant filters, aiming to lift the solids content of treatment plant waste from the 20 per cent achieved by standard centrifuges, to 40 per cent. Removing water from sewage sludges could provide the industry with major disposal cost reductions, and maybe a useful end-product. Major trials indicate substantial increase in sludge solids is achievable, probably cost competitive with traditional methods.
- A multi-disciplinary study of climate, plant, soil, water and nutrient interactions led to draft guidelines for effluent-irrigated eucalypt and pine plantations, a preferred option for disposal of nutrient-rich effluent, since they use more water and require less management than agricultural crops. They also help meet wood supply needs.

Storing salt out of harm's way

CSIRO is working with many collaborators on a more sustainable response to the massive problem of salty drainage and groundwater in the Murray-Darling Basin. Specially designed ponds in irrigation areas will let salt water leak slowly into the groundwater, giving longer pond life and time to find more sustainable solutions.

Australian aquatic invertebrates

- CSIRO has produced a user-friendly interactive identification guide to Australian freshwater macroinvertebrates down to the family level, important to those studying aquatic ecosystems and monitoring the health of our waterways, including voluntary groups such as Waterwatch. For those needing identification to species level, a fully illustrated guide to the immature stages of midges has been published under the auspices of Australian Water Technologies.
- Wood-eating elmid beetles, found in running water, are the main macroinvertebrate modifiers of wood in south-eastern Australian streams, CSIRO has found. They strongly prefer *Eucalyptus* over other types, including non-native softer timbers. Where elmids were abundant - in forest streams bordered by native vegetation - immersed *Eucalyptus* supports many other macroinvertebrates. In open grassland streams, with no elmid beetles, *Eucalyptus* supported few other macroinvertebrates.

Dynamic rainforests

Helpful in steps to conserve Australia's northern rainforest is the discovery of their dynamic nature. Once thought to have been fairly static for several millennia, they have in fact undergone a 5-fold expansion in area since the last ice age. CSIRO carbon-dating reveals that 5,000 years ago some 90 per cent of the present rainforest area was dominated by dry eucalypt woodlands with frequent fires. The return of rainforest to such a landscape has been possible because a network of precious refuges allowed the forest to re-invade after suitable climatic conditions returned. Studies of soil fungal spores show this expansion may be continuing. Rainforest areas, such as the well-known Daintree region, were still covered with eucalypts only a few centuries ago.

MARINE SECTOR

How oceans absorb and cycle carbon dioxide

A CSIRO bio-geochemical model of ocean carbon cycling is part of the understanding essential for monitoring carbon dioxide emissions from terrestrial sources. It has been used to quantify the rate of ocean absorption of carbon dioxide in the present climate, and predict change in future Greenhouse scenarios, and can also be applied to enhance understanding of marine ecosystems.

Strategies and indicators for marine monitoring

CSIRO led development of a multi-agency report on strategies and indicators for monitoring the state of Australia's marine environment. It looked at all major elements of our marine environment, particularly the high-use coastal zone. It also reviewed the strategy and indicators developed by New Zealand.

Commonwealth fisheries sustainability improved

CSIRO provided stock assessments and management strategy advice as the scientific base for the ecologically sustainable management of several major fisheries including the Northern Prawn, East Coast Tuna and Billfish, and Torres Strait fisheries. With the fishing industry, Queensland Department of Primary Industry, and the Australian Maritime College, CSIRO completed a project developing and testing bycatch reduction devices. The results contributed to industry and management agreement for compulsory adoption of such devices in the Northern Prawn Fishery by 2000.

Ocean forecasting by satellite

Real-time mapping of three-dimensional ocean structure and currents from satellite imagery and historical data is under trial by CSIRO and the WA Fisheries Department. The trials aim to predict breeding success in a rock lobster fishery, movement of objects in the sea for search and rescue, and identify events giving natural nutrient enrichment near a sewage ocean outfall. Techniques have been developed to determine ocean currents by using data from concurrent satellite passes occurring within 6 to 24 hours. Part of this work has been supported by CSIRO's Earth Observation Centre.

Conservation plan for Torres Strait

CSIRO used its Geographic Information System database on Torres Strait to provide a spatial classification analysis of seabed habitats, and prepare maps for the Queensland and Federal Environment Departments to develop a conservation plan for Torres Strait.

Better aquaculture production and coastal management

CSIRO, cooperating with State departments, has developed a Geographic Information System to help industry investors and environmental managers reach optimal aquaculture production and coastal zone management by appropriate site selection. Collaboratively developed software is helping aquaculture farmers improve production by monitoring environmental conditions in their ponds. Models from the data allow accurate forecasts of production cycles to meet specific market demands.

Controlling marine pest invasions

In work jointly funded by port and ballast water authorities, CSIRO's Centre for Research on Introduced Marine Pests (CRIMP) completed the field component of an Australia wide survey of ports for infestation patterns of exotic marine pests, helping build management options to minimise invasion. CRIMP is also developing comprehensive risk-analysis for ship-based sources of infection and looking for Japanese and European parasites that may be safe biological control agents.

Tracing pollution

Sources of faecal pollution in receiving waters can be distinguished using a new technique from CSIRO which has also traced hydrocarbon and faecal pollution in coastal ecosystems using advanced biomarker techniques. Major studies have monitored such matter from urban stormwater in Hobart, and the fate of oil following the *Iron Baron* spill

Advice on Oceans Policy and Marine Science and Technology Plan

Senior CSIRO staff were actively involved in the Oceans Policy development process and development of a national marine science and technology plan. Papers were commissioned by Environment Australia on scientific principles and requirements for sustainable multiple use management and for the conservation of marine biodiversity.

Modelling effluents in Bass Strait

A CSIRO study for Melbourne Water is assessing alternatives for management and disposal of treated effluent discharging into Bass Strait. CSIRO developed complex circulation and nutrient cycling models to simulate the dispersion and fate of effluent from the existing outfall and from proposed designs for extended offshore outfalls.

Environmental impacts of oil facilities

Apache Energy has drawn on CSIRO expertise to assess water quality and bottom-dwelling marine life near their new North West Shelf production well. CSIRO developed a baseline monitoring strategy to characterise the seabed ecosystem and measure effects of drilling or of installing a production platform. The team will provide Apache with an assessment of conditions and with monitoring strategies.

Adelaide coastal waters

CSIRO helped design a large integrated study of Adelaide's coastal water ecosystems. The study aims to address the complex interactions between human activities and the marine environment to enable wise decisions about the expenditure of funds on expensive capital works, such as wastewater treatment and the management of catchments. The scoping project completed by CSIRO forms the basis for decisions on the study itself.

Making international fisheries sustainable

CSIRO provided stock assessment and management strategy advice as part of Australia's input to the International Commission for the Conservation of Southern Bluefin Tuna. CSIRO also led a multi-agency project to underpin management of the developing Toothfish fishery and protect the major nearby seal, penguin and sea bird populations. It is the first study to consider explicitly a broad range of ecological issues in the early stage of the development of a fishery and its management arrangements.

Back from the brink

CSIRO biological research in Sarawak, Borneo provided advice on management strategies and the re-seeding of estuaries to save the economically and traditionally important fish, Terubok, from likely extinction.

FIELD CROPS SECTOR

Biofumigation - breaking the disease cycle in cereal crops

CSIRO has shown that brassicas such as canola and mustard are valuable break crops that reduce pests and diseases in agricultural crops. Brassica roots release highly toxic 'biofumigants' that control root fungal diseases like Take-All. Proving that the levels of these toxic biofumigants vary significantly amongst different canola varieties opens the door to a breeding program that could produce canola varieties with high concentrations of biofumigants in their roots.

Managing mouse plagues

Researchers have developed practical recommendations for farmers for early tactical management of mouse plagues in southeastern Australia grain-growing regions. They were developed during a three-year collaborative study involving Agriculture Victoria, farmers and industry representatives from four States. From a longer-term perspective, there has been promising progress in research on the biological control of mouse plagues. A multi-disciplinary study is focussing on the use of either a mouse-specific virus or bait as a vehicle to vaccinate mice to induce infertility long enough to prevent plagues developing.

Seeds without sex

CSIRO researchers have found genes that could make male plant parts in crops redundant, and dramatically lift grain production. The normal process of pollen formation and transfer is very sensitive to weather conditions and around $400 million a year is lost in rice production around the world because of drought-related pollination failure. The CSIRO scientists have found a gene that allows test plants to bypass the normal pollination process and begin seed formation. This is the crucial first step in developing plants that produce seed without pollination. The scientists are now looking for equivalent genes in commercial plants like rice.

FORESTRY, WOOD AND PAPER INDUSTRIES SECTOR

Greenhouse impact on Australian forests

A major collaborative study by CSIRO and the University of NSW has provided a more reliable means of predicting the impacts of the build-up of greenhouse gases on Australian forests. Impacts will result from the direct 'fertilising' effect of higher CO2 levels and indirectly from increases in temperatures and changes in rainfall patterns. The research built on existing mathematical models of forest growth to develop a suite of models able to provide a reliable guide to the way changes in CO2 levels, temperature and rainfall would affect eucalypt and radiata pine forests in different parts of Australia. The outcome is three linked models covering the responses of forests on time-scales from days to successive rotations, and long-term soil responses. As well as assisting forest planning and management, the models will provide valuable information on the potential of forests and the soil to reduce the CO2 build-up by storing carbon.

Timber substitutes from waste

Industrial-scale trials of a structural timber substitute made from waste paper and plastic have begun. The product shows promise of being suitable for many applications that currently use timber. CSIRO, in collaboration with Equinox Research and Development Pty Ltd, has developed this new product as a follow-on from work that produced a commercially viable "cat litter" from waste paper. The wood-fibre reinforced plastic is made using extrusion techniques and results in a material twice as strong and three times as stiff as the polymers from which it was made. It has the advantage of being water repellent and defect-free. Potential products include both flat sheets and moulded shapes. This project has the potential to make a substantial contribution to initiatives for waste paper and plastic recycling.

Managing forests sustainably

CSIRO is helping Governments implement an agreed national goal of sustainable forest management. A review of codes of practice covering plantation management in each State has been completed and further work is leading to the development of Regional Forest Agreements (RFAs) for the management of native forests. Export licenses will no longer be required for woodchips from areas covered by these agreements. Much of CSIRO's input focuses on provision of the scientific underpinning for environmentally sound management practices. The development of criteria and indicators of sustainability facilitates management of forests. CSIRO is also contributing to the implementation of the international 'Montreal Process', which has developed criteria and indicators for temperate and boreal forests, and to other international work on sustainable forest management. (See Attachment C for more on these matters).

Design and management of effluent-irrigated plantations

CSIRO has completed draft guidelines for the design and management of effluent-irrigated plantations. Irrigated forest plantations are a preferred option for land disposal of nutrient-rich municipal effluent, since they use water at a higher rate and require less intensive management than agricultural crops. They also go some way to meeting needs for more wood. Until recently, there has been little information on the best management practices for effluent-irrigation of plantations (water and nutrient requirements, appropriate silviculture, the potential for exploiting genetic differences between and within species for maximum value from the wood). CSIRO scientists used a holistic and multi-disciplinary approach to study the ecosystem processes, analysing interactions between climate, plant, soil, water and nutrients in eucalypt and pine plantations irrigated with varying amounts of effluent or fresh water. They developed a computer model to demonstrate the processes involved, forming the basis for the new guidelines.

Satellites to boost forest productivity

Several CSIRO Divisions are looking at innovative techniques for assessing forest productivity using images from satellites, and instruments on light aircraft. The project seeks better ways to monitor and model productivity in south-eastern Australia's eucalypt forests. It has also facilitated the development of greenhouse gas inventories (the contribution of forests as sources and sinks of carbon dioxide). A spectrometer has provided information on the extent of understorey disturbance, time since the last fire, and the chemical make-up of the soil. Near-infrared video images have provided data on variations in photosynthetic activity that can be analysed to provide accurate indices of stand structure, which in turn reflects on habitat complexity. As the distribution and abundance of mammals that live in forests are strongly correlated with habitat complexity, the findings suggest that airborne video imaging can help in management of forest wildlife. As well as provide valuable data on the distribution of tree species and crown size. CSIRO is also working with State Forests NSW and other forest agencies to assess its potential to supplement traditional aerial photography in forest resource assessment.

Better prediction of bushfires

Experimental high-intensity fires undertaken by CSIRO and Western Australia's Department of Conservation and Land Management (CALM) during 1998-1999 will help develop more accurate means to predict the spread of bushfires. Current methods typically underestimate a large, intense fire's rate of spread by a factor of 3-5. The experiment aims to generate information, applicable to dry eucalypt forest throughout Australia, about how rate of spread is influenced by the amount and type of fuel and wind speed. Major benefits will include a more accurate system for predicting behaviour of wildfires and a much sounder basis for the design of effective prescribed burning programs.

Electricity from wood waste

New technology of interest to both forestry and energy sectors is opening up the prospect of using wood waste from forest harvesting and sawmills for efficient, small-scale electricity production. Potential benefits from this CSIRO research include cost savings and replacement of fossil fuels with a renewable

energy source. The units couple a wood gasifier to a new type of gas 'micro-turbine' developed in the United States. They are designed for natural gas, LPG or diesel, but CSIRO researchers were able to run them with wood gas. The prototype gasifier was developed in the 1970s and is being modified to ensure the wood gas meets the requirements of the micro-turbines. Automated supply of chipped wood has to be developed. The scientists calculate that, to meet a typical household's electricity demand, the unit should consume wood at about 13kg per day (less than 5 tonnes per year. In future it may also be possible to connect the unit to the power grid to draw on it at times of high demand and sell surplus electricity at other times. CSIRO expects to demonstrate feasibility by the end of 1998 with generating units, in the range of 30-200 kilowatts, on the market in five years.

A natural approach to pulp bleaching

Trials, by CSIRO and the Technical Research Centre of Finland, have confirmed the potential for environmentally friendly bleaching of eucalypt kraft pulps. Using the enzyme laccase and a chemical mediator in the presence of oxygen has achieved a 35% reduction in lignin content. A high level of pulp brightness was attained with subsequent use of chlorine-free bleaching chemicals such as hydrogen peroxide. At this stage, costs and some remaining environmental concerns, rule out commercial application. As chemical mediators appear to be involved in the natural breakdown of lignin in wood, further study of the action of laccase in nature may lead to a more effective, cheaper and safer mediator.

Breeding resistance in pines - the environmental alternative to chemical disease control

Dothistroma septospora , the most serious fungal disease affecting Pinus radiata here can be controlled by fungicide - but this is costly and environmentally questionable. A recent CSIRO study aims to identify genetic markers to help breeding for resistance as an alternative method of control. Three markers that conferred resistance were identified. One accounts for a large proportion of the genetic variance for fungal resistance but this resistance appeared to be recessive. Two others showed significant associations with resistance. Further analysis will be undertaken to determine the efficiency of using molecular markers to predict Dothistroma resistance.

Tea Tree - boosting oil production

Tea tree oil quality and yield from Melaleuca alternifolia varies dramatically between areas of seed origin. This finding from a collaborative CSIRO /NSW Agriculture study has important implications for the tea tree oil industry, one of many possible beneficial uses of native Australian plant species. Improved productivity through selective breeding of high yielding trees will help keep the industry profitable. A trial of trees from three provenances revealed the best provided a yield three times that of industry standard seed and double that of selected nursery seed. These results show that increase in productivity by as much as 60% by the year 2000 is highly possible, with consistent and desirable quality. Our tea tree oil industry has started to see the benefits of this research with the 1997 release of seed from better selected provenances. The seed orchard is expected to start producing improved seed gradually from 2000.

CD ROM shows what remote sensing can do

Three CSIRO Divisions collaborated to develop a CD-ROM to demonstrate the use of remote sensing in forest operations. It presents the results of a four year study of applications of satellite imagery and other forms of remote sensing in forest management and conservation, sponsored by the Global Research Network System. The CD-ROM is aimed mainly at forest researchers and managers but is likely to attract interest from a wider range of natural resource managers. Further work includes developing and demonstrating applications of remotely sensed data to hydrology, desertification and oceanography.

Improved harvesting technologies

CSIRO has been improving the efficiency of roading, harvesting and log transport, all of which have a major impact on the forest environment and on the cost of delivering wood to the mill. While the type and weight of harvesting machines are major causes of soil deformation, their impact can be minimised by managing traffic patterns through predictive guides for likely time and location of machinery damage.

Researchers collected traffic data by fitting machinery with global positioning systems to help map the spatial pattern and density of snigging paths, where logs are dragged out. These data were related to observations on soil compaction and soil condition and type. A computer model has been developed to predict the amount of traffic and the location of major trails. It can evaluate the likely costs of log extraction using terrain and machinery data for alternative trail locations and snigging rules.

Another improvement to harvesting technology and practice are modified excavators for log extraction from stump to roadside. Adverse effects on the soil are reduced by passing the logs from stack to stack across the coupe to the landing. Trials have demonstrated that excavator logging is economically competitive with traditional ground skidding methods for distances up to about 200 metres. The method has particular application in lower productivity and environmentally sensitive native forest sites.

MEAT, DAIRY AND AQUACULTURE SECTOR

Vaccine for feedlot cattle

A new vaccine is expected to boost cattle health and welfare, promoting a more sustainable and profitable feedlot cattle industry in Australia. CSIRO, with support from the Cattle and Beef Industry CRC, and collaboration with Australian pharmaceutical company, Ausvac, has developed a vaccine to protect cattle from bovine respiratory disease, which can cost $50 million a year in production losses. The vaccine has performed very well under field trials and is expected to complete registration in 1999.

Biological control of worm parasites

CSIRO has achieved proof of concept that nematophagous fungi can control economically important worm parasites of sheep under grazing conditions. Trials using the spores of a particular fungus fed in a grain supplement showed that pasture levels of the parasites could be maintained at a sufficiently low level for an extended period to improve sheep performance and remove the necessity for treatment with chemical drenches, an environmental gain. CSIRO is now collaborating with an Australian and a British company on development and registration of products to deliver this parasite control to grazing livestock. Biological control will help farmers keep animals healthy with less chemicals.

Control of nodding thistle

Nodding thistle is a weed currently limited to the tablelands of NSW with localised infestations in S-E Queensland, Victoria and Tasmania. In 1988 CSIRO scientists released the receptacle weevil, followed in 1991 by the seed fly, and the rosette crown weevil in 1993. All three agents have established in the field. Rosette weevil is established at several sites, causing death of some plants and indirectly reducing seeding by 70%. Models indicate that weed populations should decline if seeding is reduced by 65%. Up to 98% attack by the seed fly has been recorded on some sites with 50-70% seed reduction. Both the seed fly and the rosette crown weevil are being redistributed by community groups. Current work in CSIRO concerns integrated weed management where the focus is on interaction between rosette growth, grazing animals and the rosette crown weevil.

Aquaculture production and coastal management

CSIRO, through cooperative projects with several State departments, has developed a Geographic Information System to assist industry investors and environmental managers to optimise aquaculture production and coastal zone management through appropriate site selection. Computer software developed in collaboration with the CRC for Aquaculture is assisting aquaculture farmers to improve production by monitoring the environmental conditions in their ponds. Models derived from the data are allowing accurate forecasts of production cycles to meet specific market demands.

Pasture snails

Introduced Mediterranean snails contaminate stock feed and grain with slime and feed on legume-based pastures. CSIRO is investigating chemical and cultural controls and introduction of parasitic flies from the snails' countries of origin for biological control. Researchers have found that windrowing, and slashing and rolling of weeds, expose the snails to higher temperatures, which can kill them, and that fire and tillage

are effective controls although undesirable for soil conservation. Promising parasitic fly species were identified and host specificity testing in quarantine narrowed the field to one. Permission has been sought for its release in the 1998/99 Australian summer.

Fatty acid profiles of Australian finfish

Scientists in CSIRO, with support from the Fisheries Research and Development Corporation, have analysed the lipid and fatty acid profiles of over 200 species of marine finfish. The findings provide a significant nutritional reference, and are of enormous value to anyone trying to advise on dietary fat and fatty acid intake from seafood.

BUILT ENVIRONMENT SECTOR

Improved adhesion to polymers

Bonding of adhesives and paints to polymers such as polypropylene has previously only been possible using costly, environment-damaging solvent-based materials or expensive batch processing techniques. CSIRO has developed an environmentally friendly process that matches the best of these techniques and can be integrated into high throughput manufacturing. A ten year $16 million licence agreement will see a US building products company use the technology to treat recycled polyethylene-based products.

A new perspective for water systems

Australia's urban water systems are facing increased demand and escalating remediation costs in an environment of community and political resistance to the construction of new dams or increasing water bills. The multi-billion dollar cost of urban mains replacement is expected to treble over the next 20 years as much of the infrastructure from post WWII days has reached its use by date. A new project will provide a fundamental rethink of how these services are currently delivered, developing new concepts for sustainable urban water systems. It will investigate alternatives that will provide a closer integration of water and material recycling loops with the natural environment, identify ways to minimise waste and primary resource consumption and substantially reduce the financial burden that currently faces Australia.

Clean air for Sydney 2000

Many modern buildings are causing increased ill-health because of the volatile organic compounds and other pollutants that are emitted by building materials, paint, carpets, furniture and office equipment. The national cost of poor internal air quality has been estimated at $12 billion per year. CSIRO is leading the way to a better internal environment with Indoor Air Quality Guidelines for the Sydney Olympics, developed in collaboration with Green Games Watch and the Olympic Co-ordination Authority to ensure a human-friendly environment for spectators and participants. The landmark document will support national guidelines that will put Australia at the forefront of clean air construction and significantly reduce the nation's health bill.

Gold Coast transport study

Improved public transport is one of the most pressing issues facing Australia's fastest growing city. With traffic levels forecast to double in less than 20 years, a desire to minimise the environmental impact of transport and a rapidly growing population of elderly people, the Gold Coast City Council has joined forces with CSIRO to develop a more effective public transport system. CSIRO research on 'intelligent transport systems' has led to software that can simulate existing bus, rail and taxi services combined with new 'demand-responsive' services that could be booked by phone, Internet or via roadside kiosks.

Measurements helping effluent treatment

The Rapidly Assimilable Chemical Oxygen Demand (RACOD) Meter is a patented CSIRO technology, which provides on-line measurement of Biochemical Oxygen Demand (BOD) for sewage and industrial effluents. Valued at approximately $1 million, the technology has been licensed to US FILTER Wallace and Tiernan Pacific, who have already sold ten units to Scottish Water and are launching the meters worldwide in1998-99. Their use will improve the effectiveness of treatment technologies

Replacing air conditioning with nature

CSIRO has developed software to simulate airflows and temperature changes and demonstrate that natural ventilation can be the most cost-effective solution to an air-conditioning problem. Projects at the Sydney Fruit Market, Manly Hydraulics Laboratory and a copper smelter have successfully shown that natural ventilation can achieve acceptable levels of comfort without detriment to the environment.

CHEMICALS AND PLASTICS SECTOR

Progress with mycoinsecticides

CSIRO is collaborating with the Bureau of Sugar Experiment Stations and two commercial companies to develop insecticides based on spore formulations of the fungus Metarhizium. In large scale testing in sugarcane, the fungus is applied well below the soil surface during planting and persists to infect and kill any greyback canegrub larva which contact it. These infected grubs may produce new spores, augmenting the amount of lethal fungus in the root zone. It is hoped that a single application will give control for several years. While only one such biopesticide is registered at present, it is expected that others will be so over the next few years, giving a much needed, environmentally desirable biological alternative for control of pests such as locusts, canegrubs, termites, crickets, and even nuisance flies.

Crops as industrial feedstocks

CSIRO scientists, in an international team, have developed a technology that could enable crop plants to produce raw materials needed to make industrial chemicals and polymers. The team has identified genes which, when introduced into plants, could see them operating as mini factories, an alternative to petrochemical oils. As the genes identified come from wild plants not suitable for farming, scientists are now working to introduce the genes into oilseed plants. The research presents new opportunities for novel crops that farmers can utilise in their management systems to fill niche markets.

Lepton Test Kits

A few species of heliothine moths represent the most significant insect pests of broad-acre agriculture. The problems are compounded by the fact that there are two different pest species, which respond differently to insecticides and are difficult to tell apart. This has been a factor in inappropriate use of damaging chemicals. CSIRO has developed a diagnostic technology licensed to Abbott Laboratories and marketed as the LepTon(Test Kit. Manufactured by an Australian company, PanBio Pty Ltd, it has been available in Australia since 1993. In 1995 CSIRO began a collaborative R&D program with Abbott Laboratories to develop a test for use in North America. Since the pest species there are different, new reagents were developed to discriminate between the American species and perform well under field conditions. In 1997, pre-commercial field trials of a prototype kit were conducted successfully in the U.S.. CSIRO has worked with Abbott Laboratories and Panbio Pty Ltd to transfer the technology and optimise production techniques. The US kit is now on the market.

INTEGRATED MANUFACTURED PRODUCTS SECTOR

Sensitive remote sensing

The world's most sensitive commercially available airborne remote sensing equipment has come out of a collaborative effort in which CSIRO has developed three sensors for Integrated Spectronics Pty Ltd. Two delivered to an American service company and are now flying surveys throughout the world. The third is being used by Integrated Spectronics within Australia to form the basis of a new remote sensing service company. Remote sensing is of major importance to improving natural resource management.

ENERGY SECTOR

Sustainable energy concept

Through a six-month study, CSIRO has demonstrated the engineering design feasibility for a hybrid solar/fossil fuel system and have sourced major components, including a solar dish, microturbines and fuel cells. The project, with major funding from the Executive's Special Project program, offers efficiencies

double that of today's coal-fired electricity generators. It will combine available and emerging energy technologies in an innovative way capable of virtually eliminating greenhouse gas emissions. A key element is converting solar energy to chemical energy, allowing storage and transport. The medium for reforming is methane gas, which can be sourced from coal, natural gas or coalbeds.

Reclaiming fine coal

The feasibility of a process for the recovery of fine coal from washery tailings streams has been proven in 20 tonne-per-hour pilot-plants at two Hunter Valley collieries. The process attaches light fine coal to oil droplets leaving the heavier unwanted mineral particles in free suspension. This makes recovery of the fine coal more efficient and reduces the amount currently wasted and left in unsightly tailings ponds. Since 5 million tonnes of coal are discarded with tailings each year at a value of about $50 per tonne, there is considerable scope for applying the process to the benefit of the industry and the environment.

Battery for Brisbane hybrid-electric bus

CSIRO has designed a gel battery for a revolutionary hybrid electric bus being developed in Brisbane. This novel bus is expected to have performance and lifetime costs similar to diesel-powered vehicles, but emit considerably less pollution. The maintenance-free CSIRO battery is the world's to combine gelled-electrolyte and high compression - offering significant life improvement. Moreover, the daily driving range of the bus, and other electric vehicles, can be greatly increased by CSIRO's advanced fast-charging technique - recently developed for the international Advanced Lead-Acid Battery Consortium

Adding value to coal

In continued collaboration, CSIRO and industry partner White Industries, have committed$15 million over two years to a demonstration plant for ultraclean coal. Government and industry are also providing funding. The plant will enable researchers to evaluate the economics and environmental acceptability of the process. In addition, CSIRO has signed a joint agreement, worth $2.2 million, with major Japanese companies and the Japanese Centre for Coal Utilisation, to test ultraclean coal in gas turbines, marine diesel engines, boilers, furnaces and emerging combustion technologies. Success would give Australia's coal industry a major value-added export, and reduce environmental damage per unit of coal used.

Saving energy and improving the efficiency of cleaning waste gas

CSIRO continues to contribute to the increased efficiency and environmental acceptability of coal-fired power stations through optimising the filter bag systems used to trap flyash. CSIRO researchers have demonstrated significant energy savings by restricting the amount of air introduced to cool waste gas before it enters the bags. Only a small increase in the operating temperature occurs, with no adverse effect on the performance of the filter material. On a standard 660 MW module this cooling air reduction would save up to $200,000 per year. A related study has developed a monitor for filter bag shrinkage. The shrinkage rate is important for performance, and the new monitor has allowed comparison of different filter bag materials in an operating power station. Alternative and improved materials for filter bags will flow from this work and the environment will be one beneficiary.

PCB destruction technology extended to cleaning soils

CSIRO technology developed with Transgrid to destroy environmentally dangerous PCBs (polychlorinated biphenyls) in transformer oils and regenerate their electrical properties, has been extended to destroy organochlorines extracted from contaminated waste. A benefit of the CSIRO process is that no dioxins are produced - unlike incineration of contaminated waste. The technology has been licensed to Clough Engineering Ltd and Radian International to enable commercialisation in Australia and New Zealand.

MINERAL EXPLORATION & MINING SECTOR

Airborne exploration technology accelerates

CSIRO is working with the World Geoscience Corporation on a strategically important project funded through a $9 million grant from the Commonwealth Government's R&D START program. The project will provide the mineral exploration industry with a unique and high-value geophysical mapping capability

by combining four geophysical techniques (magnetics, radiometrics, electromagnetics and mineral spectroscopy) on a single airborne platform. The outcome will be substantial advances in exploration efficiencies as well as a new generation of technologies with potential benefit in wider environmentally-orientated remote sensing applications.

International agreements for research

CSIRO is expanding Australia's capability in key R&D areas through closer technical and scientific collaboration with our neighbours. CSIRO and the Indonesian Directorate General of Geology and Mineral Resources have signed an agreement for future research collaboration. Key areas include minerals and coal exploration and mining, and environmental management in tropical terrains.

South America is a major focus of exploration and mining activity by Australian companies. CSIRO is strengthening ties with Codelco, the major Chilean copper producer, to work on R&D projects of mutual interest. The collaborative relationship will allow mutual staff secondments and provision of CSIRO advisory services to Codelco. Research will be conducted in many mining-related technology areas and in mine site rehabilitation and environmental engineering.

MINERAL PROCESSING AND METAL PRODUCTION SECTOR

Single stage continuous copper making process

Research at the G.K. Williams CRC, in which CSIRO is a partner, has developed a continuous process for copper making that offers considerable economic and environmental benefits over conventional processes. Forecast costs compare favourably with conventional copper making, and continuous two stage processes. The process is currently being tested at pilot plant scale. Current environmental problems associated with the difficulties of sulphur dioxide capture are overcome as the new process produces a single gas stream, which allows simple gas collection and treatment.

Microbes break up toxic gold-mining effluent

Scientists from CSIRO and BacTech Pty Ltd, a Perth-based mining biotechnology firm, have discovered species of microbes that can devour toxic effluent from gold extraction. This opens the way for 'clean and green' processing of minerals such as gold, copper, nickel, and zinc. The bacteria break down the poisonous thiocyanate formed from the cyanide used to extract gold. This discovery, funded by the Western Australian Government, has led to development of a process for cleansing waste streams from inland gold mines, where clean water is often scarce and costly. It can make the water completely re-usable by mines that bioleach refractory ores prior to cyanide gold extraction. Alternatively, the process can be used to remove toxins from waste streams, prior to discharge into tailings dams.

PETROLEUM SECTOR

Total drilling fluids management

State-of-the-art methodology for designing and optimising drilling fluids for efficient management of shale instability has been developed with the completion of a project funded by the Energy Research and Development Corporation. The outcomes of this research have resulted in two major collaborative projects within CSIRO, supported internationally. A project with Baroid Drilling Fluids, Inc. (USA) aims to develop novel environmentally acceptable water-based drilling fluids to meet the future requirements of the petroleum industry. The aims of the research with Petronas Research & Scientific Services (Malaysia) are to develop a technical framework for drilling fluid design and to consolidate the results into a methodology for overcoming instability problems in wellbores.

Tracing pollution

Scientists from CSIRO have traced hydrocarbon and faecal pollution in coastal ecosystems using advanced biomarker techniques. Major studies have monitored the fate of oil following the Iron Baron oil spill in Tasmania and inputs of hydrocarbons and faecal matter from urban stormwater in Hobart.

Design criteria for the offshore petroleum industry

CSIRO is working with industry consultant, WNI Science and Engineering, to provide estimates of water currents under tropical cyclones for the design of offshore platforms and seabed pipelines. The team has provided estimates to Wapet for its Gorgon development, and Woodside for the new Rankin trunkline. In both cases, CSIRO developed and validated ocean modelling software against data, then WNI compiled a statistical design database by simulation of historical tropical cyclones.

PHARMACEUTICALS AND HUMAN HEALTH SECTOR

Insect bioprospecting

In a joint venture with an Australian listed company, BioDiscovery Ltd., CSIRO is collecting insect samples and develop a library of extracts from them. The extracts are screened for biologically active compounds that benefit human health or crop and animal production. With expert taxonomic advice, field teams collect from areas where permission has been granted by the relevant authorities. Samples are frozen rapidly and transported back to the laboratory where chemicals in the insects are extracted, characterised and incorporated into the extract library. It can be screened by pharmaceutical companies looking for new therapeutic drugs. CSIRO entomologists work closely with these companies and others to identify chemicals of interest in the extracts. It is believed that the project is the first time this approach has been applied to insects and their invertebrate relatives on any significant scale.