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Evaluation of research expenditure and capacity in forestry and forest products in Australia 2007-2008 and development of research

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Evaluation of research expenditure and capacity in forestry and forest products in Australia 2007-2008 and development of research

Prepared for

Forest & Wood Products Australia

by

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➢ *Summary*

Total expenditure on Australian forestry research and forest products research was $87.8 million for 2007/08. This comprised $61.0 million on forestry research and $26.8 million on forest products research and was estimated using methodology similar to that in the several previous assessments. The total expenditure represents an annual average increase of about 4.8% but a generally slow decline in real terms (0.7% per annum) since 1982. The total expenditure increased to approximately $106 million when some peripheral expenditure such as support, administration and surveys was included.

The expenditure was estimated according to broad sectors undertaking research, that is, Commonwealth, State, University and Private and also according to broad research areas. Research undertaken on native forests and exotic species plantations has generally declined whereas that on native forest plantations has increased sharply from 2001/02 to 2007/08. Similarly, research capacity has declined in areas such as pests and diseases and fire behaviour, and increased in areas such as carbon and bio-energy.

Across the four sectors, approximately 50 organisations reported undertaking forestry or forest products research and additional to this, various other organisations provided funding for research (FWPA, ACIAR, RIRDC, etc). Approximately 600 full time effective researchers and technicians were involved in research, and additionally, there were support and management staff. The research organisations ranged in size from individuals to more than 50 staff.

In 2007/08, approximately 52% of the research funds were provided directly or indirectly by the Commonwealth Government, 28% by State Governments, and 20% by private companies.

Total forestry and forest products research expenditure averaged $5.78 per hectare of managed forest. The forestry research according to forest type comprised $14.80 per hectare on exotic species plantations, $36.90 per hectare on native species plantations, and $0.99 per hectare on native forests (including environmental research). Additionally, there was expenditure of about $0.45 per hectare on surveys, and they were mainly carried out in native forests.

Total forestry and forest products research expenditure also equated to an average of $3.90 per cubic metre of harvested timber. In terms of forestry research, this comprised research expenditure of $1.02 per cubic metre of harvested timber from exotic species plantations, $7.38 per cubic metre from native species plantations, and $1.90 per cubic metre from native forests.

➢ *Introduction*

Expenditure on research in commercial forestry and forest products is an investment into the future of the industry. The forestry and forest products industries are scientifically and technically based and research is essential for continuous improvement and innovations in forest management and utilisation. The outcomes and benefits of research depend on the level of investment, the strategies for the research, the structure of the research sector itself and its relationship with the industry it supports. The present report is an analysis of expenditure on forestry and forest products research within Australia in 2007/08. The methods used were basically the same as previous assessments to allow for reasonably direct comparisons to be made.

➢ *Methods*

The two broad areas of interest are research expenditure on commercial forestry and on forest products. The definitions and methods were those used in previous analyses (Quick and Booth 1987, Lambert and Turner 1992, Turner and Lambert 1997, 2005). Some additional specifically identified areas, mainly related to forest bio-energy and carbon, were also included. Forestry research was divided into that on exotic species plantations and native species plantations, native forest and environment which, based on the initial detailed analysis (Quick and Booth 1987), was primarily soils and hydrology research spanning more than one forest management type. Forestry research mainly included research in relation to the management and protection of commercial forests, including environmental and ecological considerations. It did not include research on areas managed specifically for conservation (for example, forest areas in National Parks). Costs of monitoring such as for growth, health, nutrition or biodiversity were not included within research costs, but they were tracked separately where available to ensure there was no overlap with research as in past reviews. Costs of research management were also identified separately where available.

Research on forest products involved that on value adding to timber in its broadest sense, however, it did not include work on final product development (for example, furniture production), production runs in mills, environmental monitoring or quality control assessment.

The primary data include annual expenditure (for 2007/08) on research activities by organisations undertaking research. That is, the focus of this review was on research undertaken as opposed to the provision of funds for research. The information was obtained from direct contact with the organisations and was supported with documentation, such as annual reports, where available. Data were tracked separately from sources where multiple organisations were involved to avoid double counting, this being a potential major source of error. Data were pooled according to sector and individual private organisations were not identified.

The data were compiled within Excel spreadsheets and combined with information from previous surveys. Analyses included changes with time, expenditure according to sector, comparisons of values adjusted for CPI, and expenditure in terms of the forest estate or quantity of timber harvested.

➢ *Forestry Research*

• *Expenditure*

Estimated expenditure on forestry research in 2007/08 was $60.99 million. This represented an annual increase of about 3.1% since the last assessment in 2001/02 (Table 1). There have been significant changes in expenditure by individual sectors as a result of a number of factors, primarily restructuring within the industry. Expenditure by the University sector has increased markedly and this is partly a result of changes in State Government staff in Victoria relocating to Melbourne University and the actual larger number of Universities reporting on some level of forestry-related research. Some activity in this sector may have been missed in previous surveys.

The first estimate of expenditure on forestry research was provided by the Standing Committee in 1982 followed by assessments at five-year intervals. In unadjusted terms, expenditure on research has increased at an annual rate of about 5.8%, although in the most recent period the annual increase was 3.1%. In adjusted terms (to 1982 dollars) over the 26 years of assessments, there has been a decrease of about 0.38% per annum (Figure 1).

Table 1. *Summary of expenditure ($m) on commercial forestry research in Australia from 1981/82 to 2007/08. The annual change is a simple arithmetic estimate.*

Sector	***1981/82 * ($m)***	***1985/86 * ($m)***	***1989/90 * ($m)***	***1994/95 * ($m)***	***2001/02 * ($m)***	***2007/08 ($m)***
Commonwealth	*10.00*	*12.11*	*14.91*	*19.52*	*22.84*	*19.40*
State Organisations	*11.33*	*14.35*	*17.62*	*20.25*	*21.65*	*19.96 **
Universities	*1.07*	*1.94*	*2.22*	*2.65*	*3.37*	*14.24*
Private	*2.02*	*2.71*	*4.51*	*3.82*	*3.50*	*7.39*
Total	***24.42***	***31.11***	***39.26***	***46.24***	***51.36***	***60.99***
Annual change (%)		*6.9*	*6.6*	*3.6*	*1.6*	*3.1*

* *Previous data for 1981/82 (Standing Committee estimate); 1985/86 (Quick and Booth 1987); 1989/90 (Lambert and Turner 1992); 1994/95 (Turner and Lambert 1997); 2001/02 (Turner and Lambert 2005).*

** *Lower expenditure by this sector due to the relocation of Centre of Forest Tree Technology (CFTT) staff in Victoria to the University of Melbourne.*

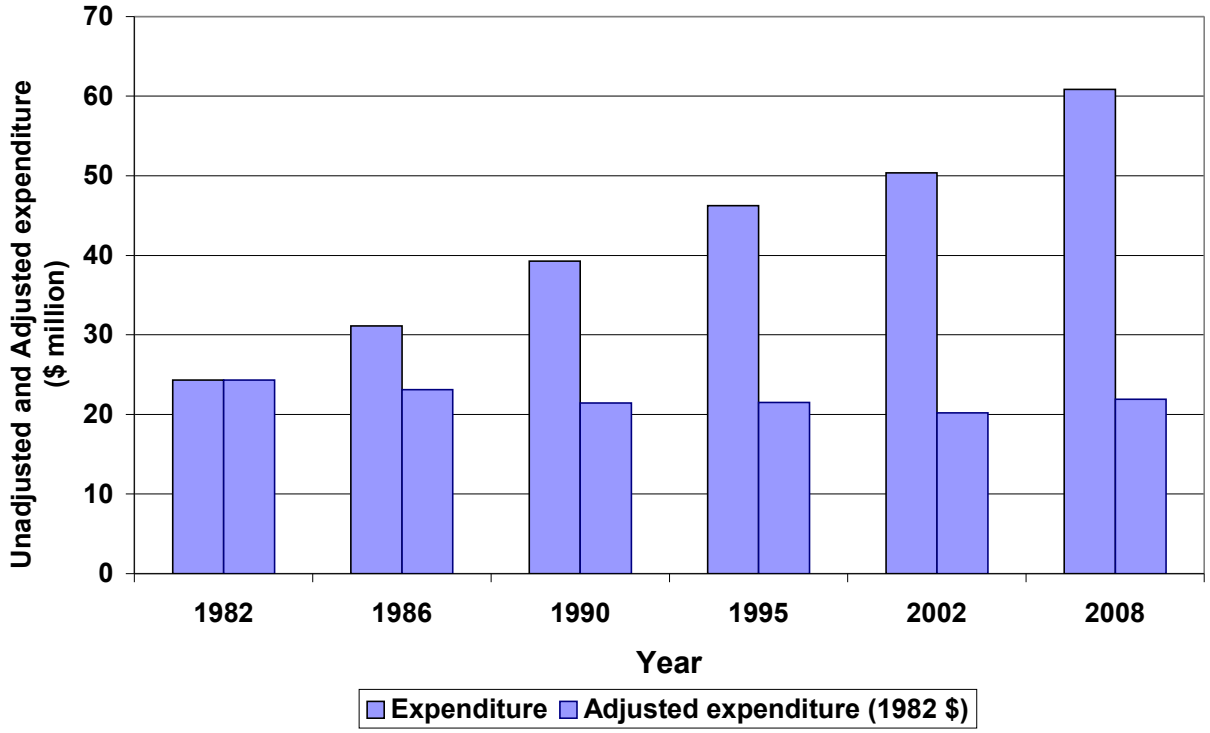

Figure 1. *Forestry research expenditure from 1981/82 to 2007/08 in both actual dollars and adjusted to 1982 dollars.*

The main sources of funding for forestry research were estimated (Figure 2). The Commonwealth Government provides direct funding for research through CSIRO and Universities. They also provide funding (as grants, matching funds, etc) through a variety of funds and organisations (FWPA, ACIAR, RIRDC, CRCs, etc) and the funds are passed on to research providers through various processes. It was estimated that the Commonwealth provided a total of about $30.02 million for forestry research in 2007/08 and spent about $33.60 million on forestry research through its organisations and Universities.

State Organisations provided funds of about $21.40 million and spent about $19.96 million. One reason for the difference between these two amounts is due to State employees in Victoria, now embedded in Melbourne University and their funding is sourced from the State but spent through the University, that is, there is a significant decrease in State expenditure and a considerable increase in University expenditure. Private companies provided about $10.16 million and spent $7.38 million. Universities appear to be the main recipients of the additional funding derived from funding bodies. Overall, we can account for about $1 million more in funds than in expenditure. Administration costs were estimated at about $8.8 million overall, however, they are difficult to determine and vary in definition between organisations and hence are one source of variation.

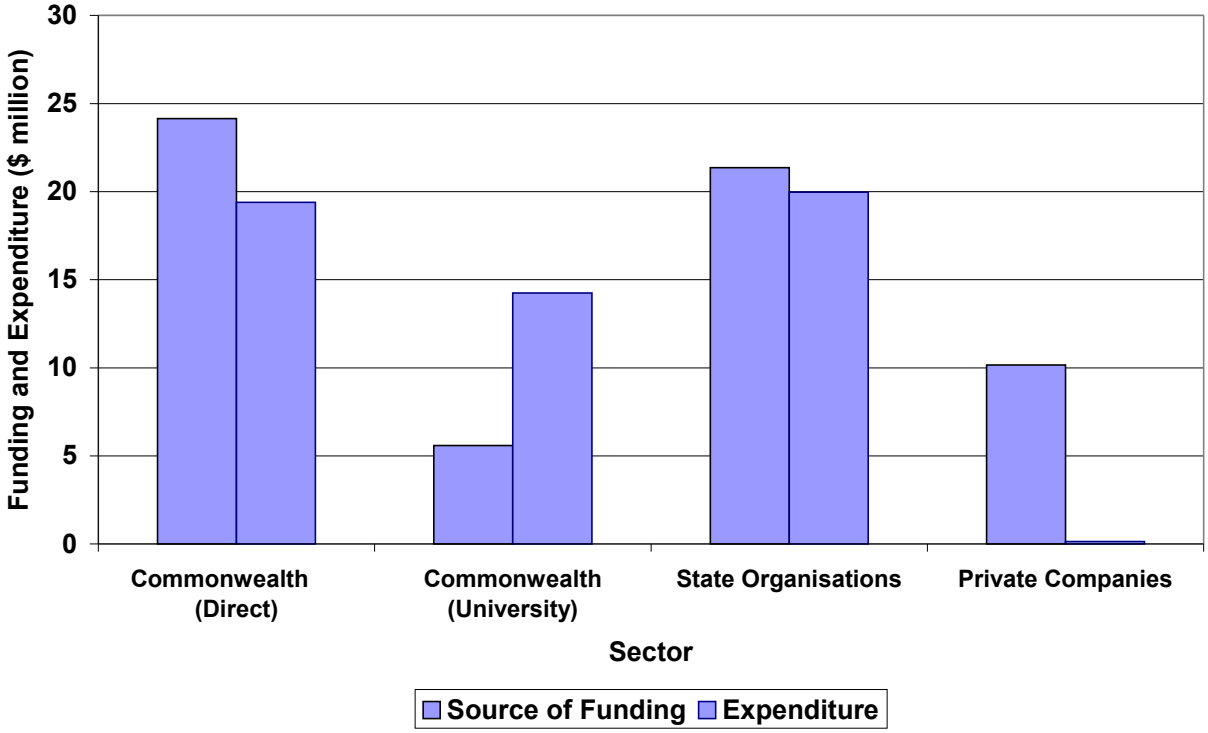

Figure 2. *Funding sources compared with expenditure according to sector for the 2007/08 year.*

- ***Categories***

Forestry research has been tracked in broad categories namely, exotic species plantations, native species plantations, native forest and environment. The environment category was originally identified for tracking research such as soil erosion and hydrology in both native forest and plantations, however, it mainly relates to native forest.

An estimate of surveys which relate to monitoring and surveys such as flora and fauna assessments and some inventory, was also undertaken. The reason for such an estimation was to ensure consistency as some organisations considered surveys to be research because the work was undertaken by the organisation's researchers, while others did not. The surveys have been reported separately to the estimates of forestry research.

The highest expenditure in 2007/08 was in the category of native species plantations (Table 2, Figure 3). This is the category where there has been the greatest expansion in recent times, although it is not reflected in terms of wood harvest or value. There has been a sharp increase in the last decade as a proportion of total expenditure. The expenditure on exotic species plantations and the proportion of this category in the total expenditure has again declined as in the previous assessment (2001/02) and this is also the case for the native forest category.

Table 2. *Broad areas of forestry research expenditure over the study periods from 1981/82 to 2007/08.*

	1981/82 * ($m)	***1985/86 * ($m)***	***1989/90 * ($m)***	***1994/95 * ($m)***	***2001/02 * ($m)***	***2007/08 * ($m)***
Exotic species plantations	*10.47*	*12.97*	*17.56*	*19.05*	*17.69*	*14.85*
Native species plantations	*0.61*	*1.04*	*1.95*	*5.61*	*15.86*	*29.92*
Native forest	*10.19*	*12.44*	*13.95*	*15.87*	*12.59*	*11.24*
Environment	*3.15*	*4.66*	*5.80*	*5.71*	*4.22*	*4.98*
Total research	***24.42***	***31.11***	***39.26***	***46.24***	***50.36***	***60.99***
Surveys	*0.55*	*0.91*	*1.96*	*3.26*	*5.41*	*7.48*

* *Previous data for 1981/82 (Standing Committee estimate); 1985/86 (Quick and Booth 1987); 1989/90 (Lambert and Turner 1992); 1994/95 (Turner and Lambert 1997); 2001/02 (Turner and Lambert 2005).*

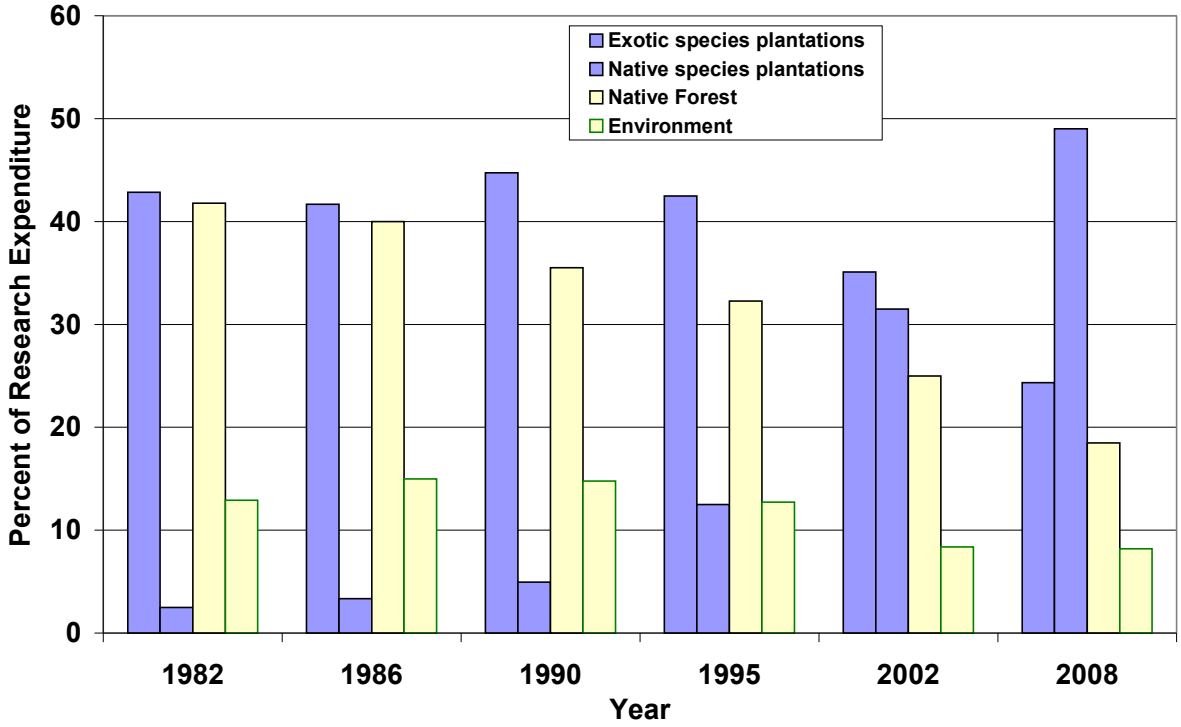

Figure 3. *Percentage of forestry research expenditure in broad research areas from 1981/82 to 2007/08.*

For each broad category, expenditure was calculated in terms of the total area of forests in that category, that is, in dollars per hectare. Areas of plantation were obtained from the Australian Forest Inventory (Parsons *et al.* 2006, National Forest Inventory 2007) and/or from ABARE estimates. In 2007/08, there was the equivalent of $14.8 per hectare spent on research in exotic species plantations and $36.9 per hectare on research in native species plantations (Figure 4). Expenditure on research in exotic species plantations is decreasing in expenditure per hectare, from a peak in actual dollars of $22.2 per hectare in 1994/1995 while research in native species plantations continues to increase. Expenditure on native forest research, including environmental research, is the equivalent of $0.99/ha and this is decreasing with time. The high point was measured as $1.23/ha in 1994/95. Additionally, there was expenditure of about $0.45/ha on surveys.

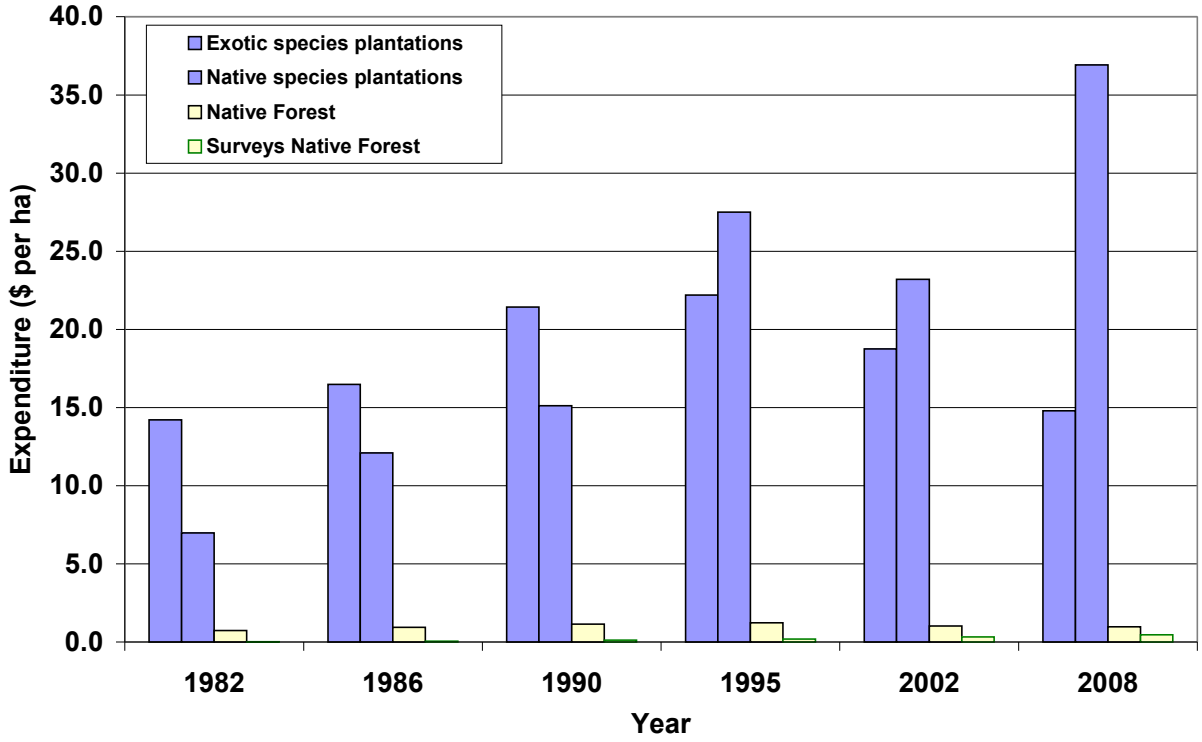

Figure 4. *Forestry research expenditure estimated in dollars per hectare according to category in the study periods from 1981/82 to 2007/08. The surveys appeared to be mainly undertaken in native forests.*

The pattern of research expenditure per unit area was adjusted to 1982 dollars (Figure 5) and the results indicated a long term decline in expenditure on exotic species plantations and native forest and an irregular increase in native species plantations. Expenditure on surveys in native forest also appears to be increasing.

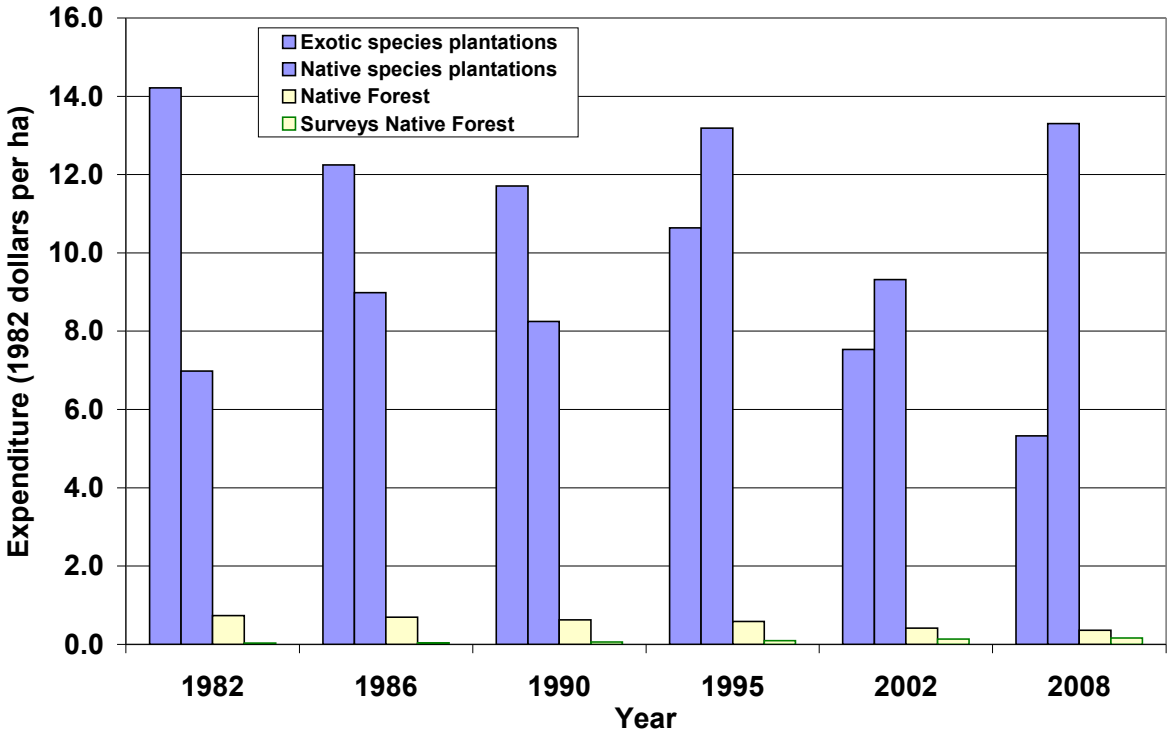

Figure 5. *Forestry **r**esearch expenditure in 2007/08 according to category adjusted to 1982 dollars.*

Analyses were undertaken in terms of forestry research expenditure per cubic metre of wood (all wood) removed from each of the broad categories. In the early survey periods, wood removed from native species plantations was not differentiated, and while it was a relatively small quantity, it was pooled either with native forest or exotic species plantations. The results in 2007/08 (Figure 6) show (in unadjusted dollars) that about \$1.02/m^3 was spent on research in exotic species plantations, \$7.4/m^3 on native species plantations and \$1.90/m^3 on native forest.

Using the index of research expenditure per cubic metre, expenditure on exotic species plantations has been decreasing over time, basically due to the increasing removals from the plantations (an increase by 3.2 times between 1981/82 and 2007/08). The category of native species plantations has been rapidly decreasing from a high level at a time when timber removals from native species plantations were low. This category is now increasing greatly over time. Expenditure on research in native forest based on wood removals has remained reasonably similar over the period of the reviews.

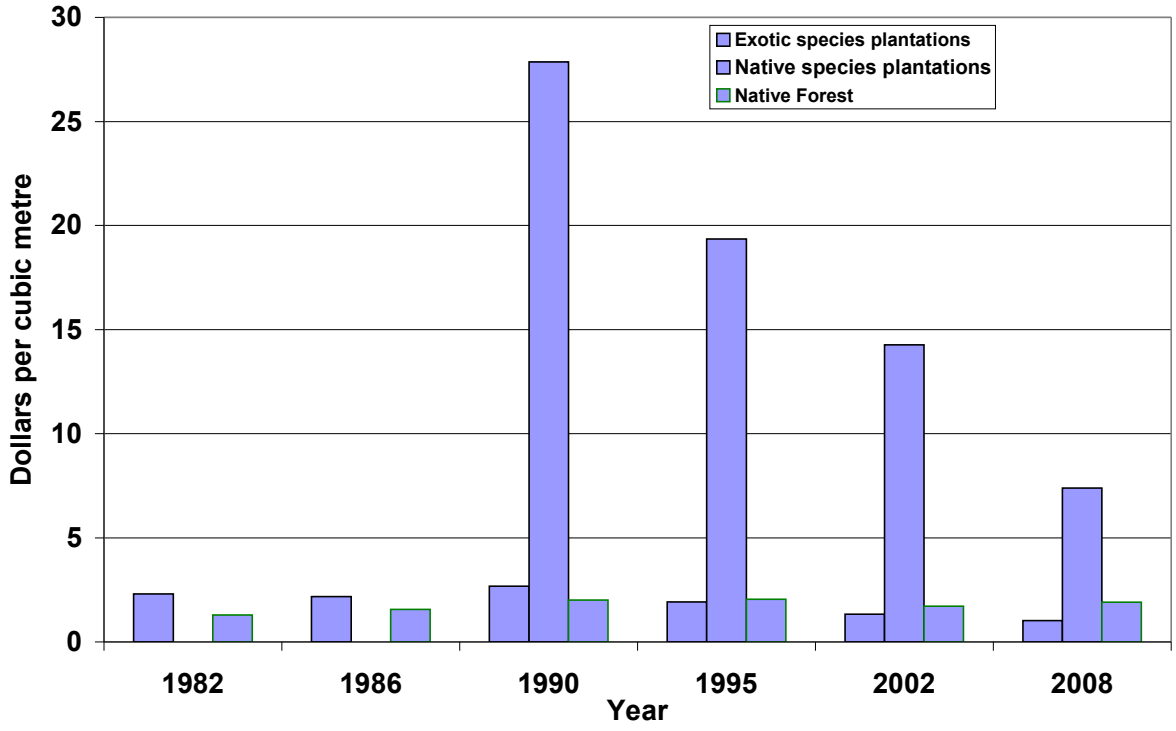

Figure 6. *Actual dollars spent on forestry research per cubic metre of wood harvested for each of the categories over the study period from 1981/82 to 2007/08.*

➢ *Forest Products Research Expenditure*

Assessment of expenditure on forest products research (Table 3) indicated that the total has increased from $19.73 million in 2001/2002 to $26.81 million in 2007/08. The total expenditure in 1981/82 was $14.3 million and the expenditure in 2007/08 was $26.81 million. Expenditure in 2007/08 was $9.66 million when adjusted to 1982 dollars. In the initial period (1981/82), private companies undertook the largest proportion of research (49.7%) followed by Commonwealth agencies (38.2%). However, by 2007/08 the Commonwealth organisations and private companies represented 46% and 24% of expenditure respectively. Estimates of the sources of funding for forest products research indicated that the Commonwealth Government provided (directly and indirectly) about $15.2 million through various agencies and Universities (Figure 7). The expenditure was about $16.2 million. State Governments provided about $2.98 million while expenditure was $4.27 million. Private companies provided $8.92 million and spent $6.37 million.

The estimates of forest products research do not include mill production runs and some other areas and hence, by comparison with other estimates (for example, the Montreal Process Implementation Group for Australia 2008) may appear to be conservative. Part of the increase from other years is the inclusion of research into the use of wood for bio-fuels. The focus of research has also changed with parts of the product work addressing wood properties to support the tree breeding work in forestry.

Table 3. Summary of e*xpenditure on forest products research between 1981/82 and 2007/08. The annual change is a simple arithmetic estimate.*

	1981/82 * ($m)	***1985/86 * ($m)***	***1989/90 * ($m)***	***1994/95 * ($m)***	***2001/02 * ($m)***	***2007/08 * ($m)***
Commonwealth	*5.46*	*5.85*	*6.18*	*9.47*	*9.13*	*12.33*
State Organisations	*1.27*	*1.41*	*1.77*	*2.16*	*1.41*	*4.27*
Universities	*0.46*	*0.56*	*0.63*	*0.59*	*2.37*	*3.83*
Private	*7.11*	*7.39*	*9.11*	*7.85*	*6.82*	*6.37*
Total	***14.30***	***15.21***	***17.69***	***20.07***	***19.73***	***26.80***
Annual change (%)	*1.6*	*4.1*	*2.7*	*-0.7*	*5.98*	
$/tonne harvested	*0.962*	*0.899*	*1.073*	*0.999*	*0.812*	*0.990*
$/hectare	*0.753*	*0.795*	*0.966*	*1.146*	*1.091*	*1.468*

***** *Previous data for 1981/82 (Standing Committee estimate); 1985/86 (Quick and Booth 1987); 1989/90 (Lambert and Turner 1992); 1994/95 (Turner and Lambert 1997); 2001/02 (Turner and Lambert 2005).*

In general, expenditure on forest products research in 2007/08 equates to about $0.99 per tonne of harvested timber (Table 3). This figure has varied a little in previous assessments between $0.81 and $1.07 but there is no specific trend. While the actual dollar value on research has increased in each period so has the total quantity of timber harvested. When considered in terms of dollars per managed hectare of forest (the sum of plantations and native forest), the value in 2007/08 was $1.47/ha (Table 3) and this has increased from $0.75/ha in 1981/1982.

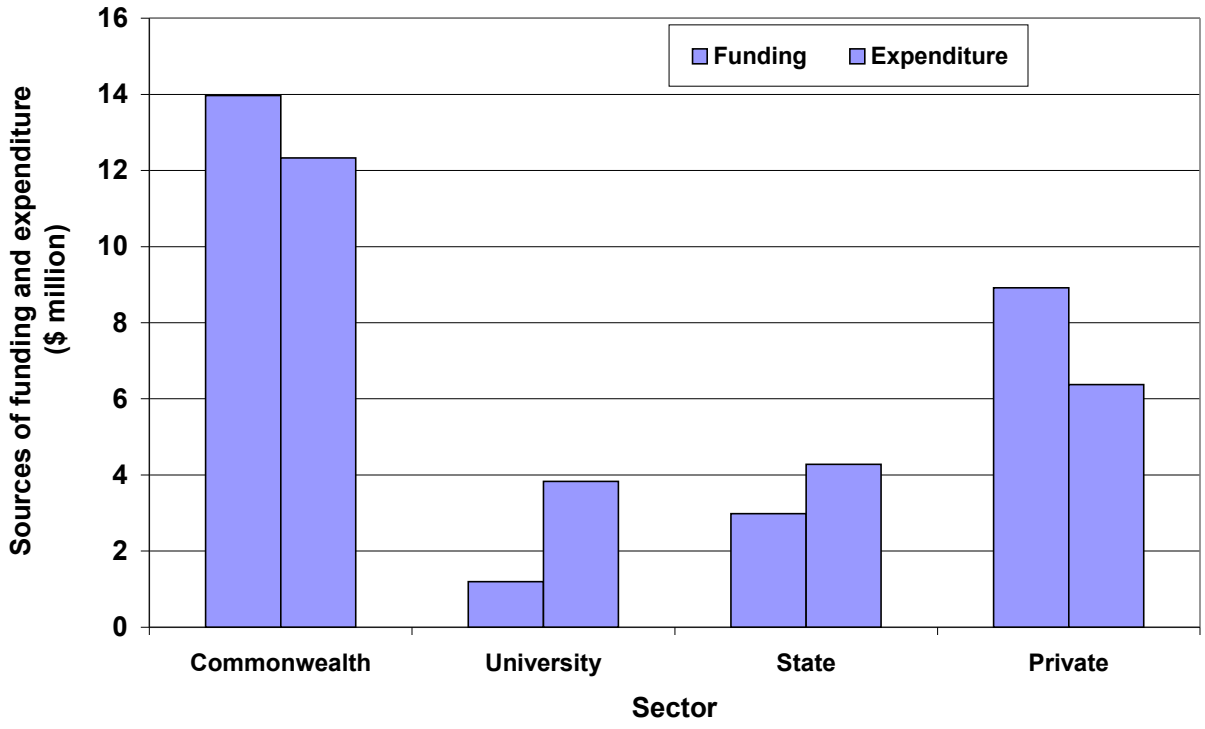

Figure 7. *Sources of funding and expenditure on forest products research in 2007/08.*

➢ *Discussion on Research Expenditure*

The total expenditure in 2007/08 on combined forestry research and forest products research was estimated as $87.80 million and this has steadily increased from the 1981/82 estimate of $38.6 million (Table 4). It was estimated that about $7.48 million was spent on various types of surveys within forests, these being tracked as they are often undertaken by the research section of an organisation. The figure may well be an under-estimate as some of this work is also undertaken in pre-logging assessments and may not have shown up in the research category. There is also an estimate of about $10.47 million spent on research administration and management. This figure does not include the costs of organisations associated with providing research funds. The overall research and technically related expenditure in Australia is about $105.75 million. The actual estimates indicate an increase in each of the assessment periods but when adjusted to a common base of 1982, there has been a general decline from about $44.5 million in 1981/82 to $38.00 million in 2007/08 (Figure 8). Fifty two per cent of research expenditure is provided directly or indirectly by the Commonwealth, 28% by State Governments and 20% by private companies.

Table 4. *Summary of total expenditure (unadjusted $m) in Australia on forestry research plus forest products research by all organisations together with administration/management and surveys in the study period from 1981/82 to 2007/08.*

	1981/82 ($m)	***1985/86 ($m)***	***1989/90 ($m)***	***1994/95 ($m)***	***2001/02 ($m)***	***2007/08 ($m)***
Forestry	*24.42*	*31.11*	*39.26*	*46.24*	*51.36*	*60.99*
Forest products	*14.30*	*15.21*	*17.69*	*20.07*	*19.73*	*26.81*
Total research	***38.72***	***46.32***	***56.95***	***66.31***	***71.09***	***87.80***
Administration / Management	*5.37*	*7.47*	*10.60*	*10.95*	*13.87*	*10.47*
Surveys	*0.55*	*0.91*	*1.96*	*3.26*	*5.41*	*7.48*
Grand Total	***44.64***	***54.70***	***69.51***	***80.52***	***90.37***	***105.75***

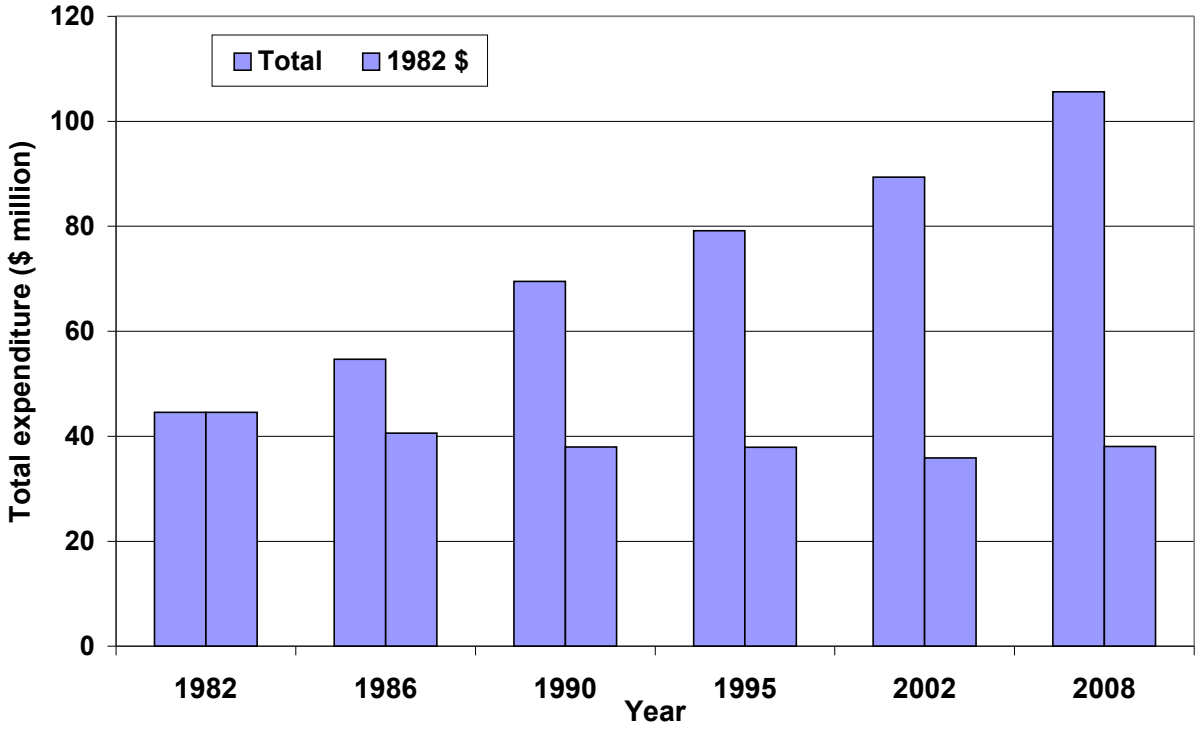

Figure 8. *Total of forestry and forest products research expenditure over the study periods from 1981/82 to 2007/08 in both actual dollars and adjusted dollars (1982 $).*

The total research expenditure has been evaluated in each period from 1981/82 to 2007/08 in terms of actual dollars spent per hectare of forest and per cubic metre of timber harvested (Figure 9). There was a general increase (in actual expenditure) in terms of the area of forests and this reflected an overall increase in expenditure with relatively small changes in the total which relates to monitoring and surveys such as flora and fauna assessments in areas of forests. In 2007/08, there was an estimated total expenditure of $5.78 per hectare. Total research expenditure in relation to timber harvested in 2007/08 was $3.90 per cubic metre. The pattern showed an increase in expenditure over the study periods from 1981/82 to 1989/90 and then a decline and tapering off. The pattern is related to the increasing quantities of timber removed from forests on an annual basis. Total research expenditure (including surveys and administration) represented about 6.2% of the total volume of wood harvested in 2006/07 (ABARE 2007) or 5.3% if research alone was considered. This is a decrease from 6.5% in 2001/02. Research expenditure estimated by the Australian Bureau of Statistics (ABS) and cited in the Montreal Process Implementation Group for Australia (2008) was about $198.9 million which is somewhat higher than the present estimates mainly due to the more specific definitions used in the present report. The ABS estimate represented 11.8% of the value of logs harvested and this would appear to be a high figure.

When expenditure was adjusted to the common base of 1982 dollars, there was a decline in expenditure in terms of category and timber harvested (Figure 10).

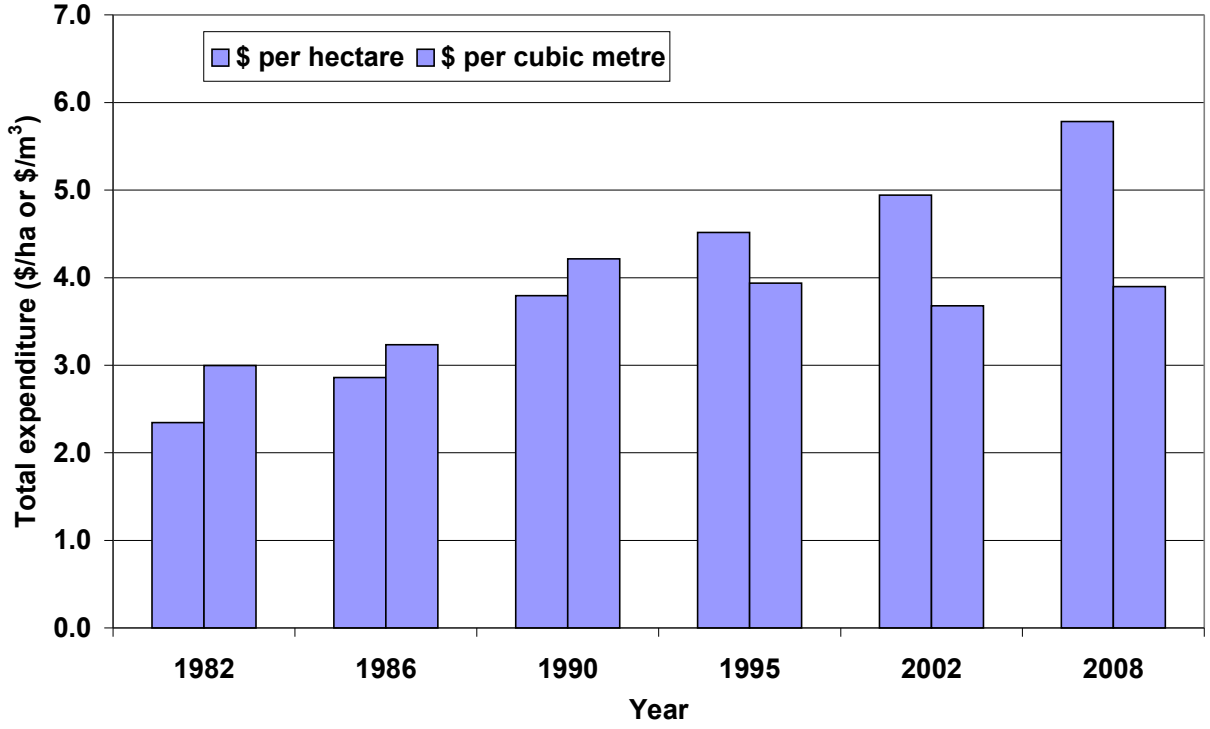

Figure 9. *Total expenditure on forestry research and forest products research over the study periods from 1981/82 to 2007/08, calculated as per hectare of managed forest and per cubic metre of wood harvested.*

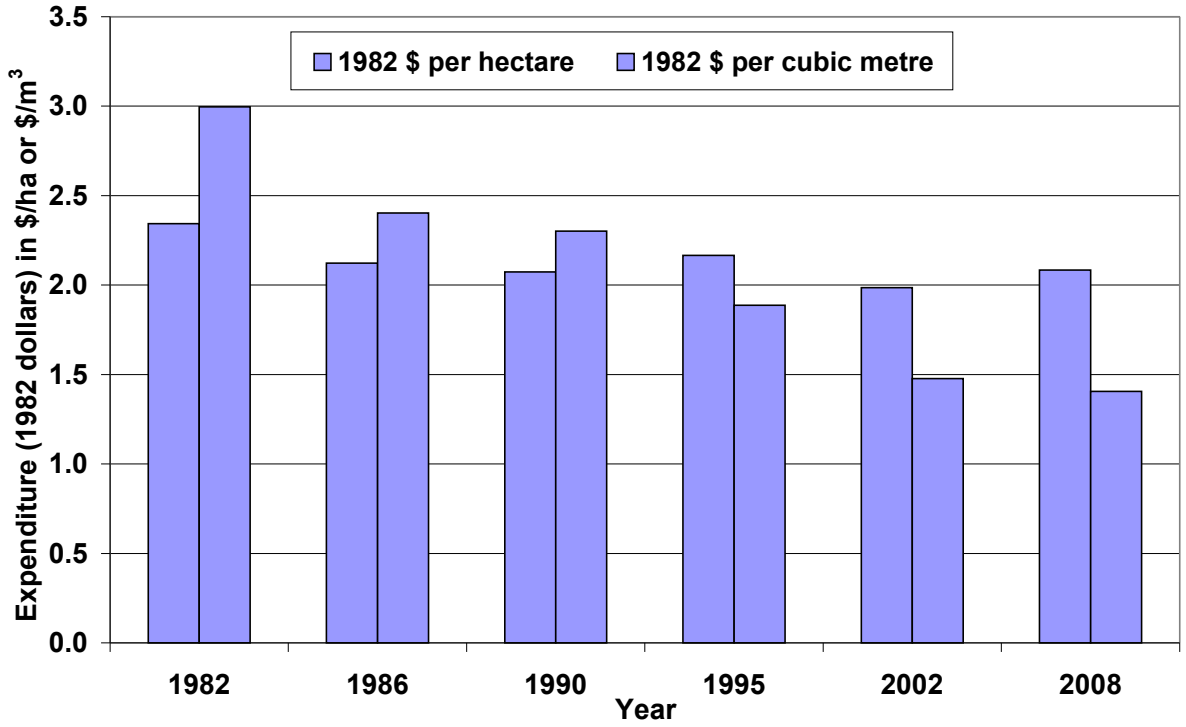

Figure 10. *Total expenditure on forestry research and forest products research in 1982 adjusted dollars for each study period from 1981/82 to 2007/08, calculates as per hectare of managed forest and per cubic metre of wood harvested*.

➢ *Research Capacity*

This analysis of research capacity and functioning is focused on research related to commercial forestry and has been considered in terms of the numbers of researchers, their skills and the overall structure of research. Other than using numbers of researchers and budgets, capacity and structure are difficult to quantify.

The general structure of research at a State level involves either State organisations or CSIRO with a significant concentration of researchers often supported by regional field crews. Most private companies are at a smaller scale and are operating either with one individual, or a very small group or they are associated with other organisations. Many of the Universities undertake research and with key exceptions (Melbourne University and the Cooperative Research Centre for Forestry), the research is largely undertaken through PhD programs which are on an individual basis and of a short term nature. The University research is significant but largely uncoordinated.

Structures and resources are considered here on a State/Territory basis as they basically relate to the forest resources. Private companies have not been identified specifically or discussed.

• *Australian Capital Territory*

Commercially managed forests within the Australian Capital Territory (ACT) are located in relatively small areas of pine (e.g. Kowen Forest) and little research is undertaken by ACT Forests itself.

The former CSIRO Forestry and Forest Products Division which was headquartered at Yarralumla represented a focus for forestry research nationally. Following a series of re-organisations and partnerships, the Division has been re-structured and amalgamated within CSIRO overall. That which was Forest Products, located at Clayton, is now within Materials, Science and Engineering and is discussed elsewhere. Part of the forestry research is undertaken within CSIRO Sustainable Ecosystems and part within CSIRO Plant Industry. Sustainable Ecosystems (about 22 scientists and 30 technical and support staff) is mainly centred in Canberra but has components within Tasmania, South Australia, Queensland and Western Australia. Research is mainly in the areas of hydrology, tree growth, carbon accumulation and physiology. The forestry component in Plant Industry has about 15 scientists with about 22 technical and support staff and a concentration on tree improvement. Some smaller projects are undertaken in specific programs in CSIRO Entomology.

The research undertaken by CSIRO is nationally important as the expenditure on forestry research is one third of the national total for forestry research while forest products research is more than forty percent of the national total for forest products research. One consideration with the current CSIRO re-structure is that it concentrates researchers within themes within CSIRO and basically enhances the expertise base, however, an alternative consideration is that without an obvious focus, forestry research will be lost within the broader objectives of the organisation. The processes for identifying research direction within the re-structured organisation are unclear (at least, from an external viewpoint) but need to be considered in relation to pressures from commercial forestry, other Government organisations (e.g. Greenhouse Office), funding bodies (such as ACIAR) and inputs to policy and regulation. The regional programs are relatively small with groups that interact and cooperate with State organisations and Universities.

Within the ACT, forestry research has been traditionally associated with the Forestry Department of the Australian National University in which there have been a number of researchers and related PhD programs in both forestry and forest products. The Department has been integrated within a larger School which appears to have a low focus on commercial forestry. Research is being undertaken on a number of projects, mainly by PhD students, but in relation to Australian production forestry in Australia, there does not appear to be the previous level of interaction with CSIRO and other organisations.

- ***New South Wales***

In New South Wales, there are very large and diverse forest resources with a range of coastal. tableland and inland native forests, State-owned and private exotic species plantations and native species plantations, and some specialty plantations which are developing.

The State, previously through the Forestry Commission of NSW and then State Forests of NSW, maintained a research organisation, investigating most of the research areas in both forestry and forest products. Through several restructurings, the research capacity in forest products has been largely reduced, and the forest resources are now managed as a commercial structure (NSW DPI Forests NSW) within the Department of Primary Industry (DPI). Forestry research is divided into that directly related to commercial forestry (Forests NSW) and that less directly related to commercial forestry and integrated into the research section of DPI (DPI Science and Research). The NSW DPI Forest Science Centre is maintained through a service level agreement between Forests NSW and DPI Science and Research , with funding from Forests NSW, Industry and the State Government CSO (Community Service Obligation). The research capacity of Forests NSW is geographically diverse and 10 researchers plus approximately 18 technical and support staff are located in Sydney, Bathurst, Tumut and Coffs Harbour. The Coffs Harbour Group is the largest with about 7 professionals and a focus on development of native species plantations (including improvement) but on its own, its long term viability could be questioned.

The head office of NSW DPI is located in Orange. but forestry research staff are located in West Pennant Hills, and on the South Coast (the total is approximately 36 staff). The research and technical work includes forest health, biodiversity, growth and aspects of carbon accounting. There are interactions with researchers in Forests NSW and with other sections in NSW DPI, CSIRO, CRCs, Industry, Universities but the structure and function in relation to commercial forestry research require further analysis.

No CSIRO researchers working on forestry or forest products are located within NSW; although some research on NSW forests has been undertaken (an example is the Bago State Forests project).

In a number of Universities in NSW, research in forestry-related areas is undertaken mostly by graduate students. They include Southern Cross University both in the Forestry School (part of Coastal Management) and the Centre for Plant Conservation Genetics, the University of New England (mainly related to biodiversity), the University of NSW (hydrology and timber engineering), the University of Technology Sydney (Timber Engineering), Wollongong University (fire and biodiversity), Charles Sturt University (forest water use), Sydney University (bushfire research through the Bushfire CRC) and Macquarie University (biodiversity). Contacts and interactions appear to be mainly on a personal basis and much of the work is undertaken by individuals, or if related to forest products, through industry related groups. From an industry viewpoint, there appears to be limited coordination

Research by private forestry companies is reasonably low key but is both developing and diverse. Research by private companies in the area of forest products is in specific locations and includes research on energy, timber conservation, paper and timber preservation.

- ***Queensland***

Commercial forestry in Queensland includes some native forests, a mature coniferous plantation estate including some high value species, and developing hardwood plantations. There is increasing interest in high value tropical species such as *Tectona* and *Khaya*.

The main research resource in Queensland is through the Horticulture and Forestry Science Unit within the Department of Primary Industries and Fisheries, which became part of the new Department of Employment, Economic Development and Innovation in March 2009. This organisation undertakes both forestry research (Forest Technologies Group - FT) and forest products research (Innovative Forest Products Group – IFP). FT has about 17 scientists and 11 technical staff, and a large proportion are currently located as one group at Gympie. The expertise covers tree improvement, silviculture and environmental studies. A small part of this group (forest health) is located at Indooroopilly and another small component is in Mareeba in North Queensland, working on tropical plantation forestry. The IFP Group of 10 scientists and 10 technical staff are mainly located in Indooroopilly working largely on timber product and process development, and on wood properties, in part supporting the tree improvement programs. A smaller number of the staff are at Salisbury at the large timber processing research facility.

The research organisation was split from the original forest plantation management area (which became Forestry Plantations Queensland, FPQ) and was reduced in numbers. Over the last five years, there has been a build-up of direct State funding for forestry and forest products research, and current staff numbers should remain stable. Increases would be with support from additional external funding. Key points are:

- The State research organisation does little direct work for the State forest management agency (FPQ). For example, most work is on hardwoods, with only limited wood quality work on pine for FPQ. They are funded directly by the Government or by external funds, with only a small amount by contract from the forest management agency).
- The main aim is well identified and is to maintain significant effort (critical mass) in key areas to support the developing hardwood plantation industry. In the future, some State employees will be working within the University of the Sunshine Coast to increase the critical mass in tree improvement, propagation and plantation modelling.
- Other research is undertaken by a small group from CSIRO at Cooroy and a small private industry group.

A significant amount of research is undertaken by the University of Queensland in several Departments (this covers a range of topics mainly related to native or exotic hardwoods). Other projects are currently undertaken (mainly by PhD students) at Griffith University, James Cook University and the University of the Sunshine Coast.

The overall structure of forest research involves a large central group interacting with several smaller groups and covering the main areas of hardwood tree improvement, silviculture, soils, health and agroforestry. This represents the main research effort in Australia on sub-tropical and tropical forestry.

- ***South Australia***

All of the forest estate in South Australia is plantation, of which 75% is coniferous, together with a well-established processing industry.

Most of the forestry research in South Australia is undertaken by Forestry South Australia (trading name Forestry SA) with a total research staff of approximately 24 (FTEs). This comprises 7 professional researchers and 17 technical and field staff. The staff are located at Mt Gambier with the exception of some located in the Adelaide Hills and the focus is on coniferous plantation research as well as some *E. globulus* and native forest research. The skills base is in the areas of silviculture, water use, growth and model development, health, and some wood properties work. This is probably where there is the main concentration of research on coniferous plantations in Australia at this time but the group is considered to be near the minimum size for longer term viability. Primary Industry Research South Australia (PIRSA), which was originally part of ForestrySA has primary responsibility for CSO works but has some capability for research, although most is contracted to ForestrySA.

Forestry SA cooperates with other organisations in the region including the Southern Tree Breeding Association with five research staff and a focus on tree improvement. The CSIRO presence has declined in the last few years with a small group working through CSIRO Sustainable Ecosystems on water use and growth (as of March 2009, they no longer exist). There are a number of private companies with small groups mainly working in the areas of tree improvement and silviculture. University-based research in this area appears to be minimal. Southern Cross University has a teaching program in the area but there does not appear to be a significant related research program.

The research program of Forestry SA is well structured and focused and closely aligned with industry requirements and is a major focal point on research into coniferous and *E. globulus* plantations and some native forestry research.

- ***Victoria***

Forest resources in Victoria include an extensive and variable native forest estate and extensive privately owned coniferous and hardwood plantations.

The research structure is probably the most diverse in Australia. When plantations were owned by the State Government, there was a large native forest industry and there was also a very strong research structure in the State (the Centre for Forest Tree Technology - CFTT). After the sale of the plantations, CFTT remained as a separate research organisation. Other research was also undertaken through the Arthur Rylah Institute. Approximately four years ago in conjunction with re-structuring, the CFTT became functionally part of the University of Melbourne. The main impetus for this was to broaden the expertise base and address critical mass issues and gain improved interaction with postgraduate students.

The State organisation managing native forests and also some private companies then contracted to the University for CFTT expertise and that of some other University Staff members. Structurally, the research does not appear to be a single entity working under direction but is a series of small groups working on shorter term applied research. In conjunction with this, research is also undertaken by graduate students. It may be described as a loosely structured organisation with about 49 scientists and 8-10 technical staff plus graduate students in 2007/08. Funding is obtained from diverse sources and this affects the directions of research. The expertise covers a wide range of areas including native forest ecology and management, plantation health and management, hydrology and forest products, however, the forest products research capacity has reduced somewhat since the CRC for Wood Innovations ended in June 2008. There are strong linkages, either in research cooperation or on a contractual basis, to other research organisations

including CRCs, CSIRO and private companies. Some of the areas of expertise previously in CFTT have been reduced because staff retired or left the organisation.

While the current structure was established initially as one of convenience, it has potential value as one model for forestry research but there are some areas for concern. It would be of value to review the structure and function as a model for undertaking research in a number of areas and also for addressing critical mass. The forest catchment hydrology unit related to plantations is probably the strongest remaining since the end of the CRC on Catchment Hydrology.

Research is also being undertaken by CSIRO on forest products at Clayton and this remains the largest group in this field in Australia. Across various areas, there are approximately 26 scientists and 28 support staff. The research programs support industry areas and also work undertaken in the forestry programs of CSIRO Plant Industry and CSIRO Sustainable Ecosystems.

Private company research within Victoria is mainly undertaken by small groups or individuals. Research is also undertaken in forestry areas and forest products in Universities (in addition to the University of Melbourne) at Monash University and Swinburne Institute of Technology. This research is mainly through PhD students on individual projects.

Victoria has a significant resource undertaking research in forestry and forest products. The actual structure and function of this resource probably needs further analysis to better identify their directions and longer term viability.

- ***Western Australia***

The forest resources in Western Australia include moist and dry native forests, softwood plantations, extensive hardwood plantations and developing specialty plantations such as sandalwood.

State Government Research is undertaken by the Forests Products Commission (FPC) primarily on plantation forestry and products, and the Department of Environment and Conservation (DEC) into native forests and the environment. There are some areas of interaction and cross-over. FPC concentrates on plantation forestry with an overall staff of 20. They are located in diverse locations covering three broad areas (Research and Development, Tree Breeding, and Resources and Planning). The DEC is involved with native forest management and has an overall research staff of 24 plus some additional staff assisting with inventory.

CSIRO has a (small) presence in WA, mainly working on plantations and undertaking some cooperative research with FPC and universities. There are individual researchers within private companies and this has primarily been in relation to tree improvement, clonal forestry, operational research on existing plantations or developing areas. The research structures are quite diverse with limited interaction.

It was proposed previously that a State Government sponsored Forest Science Centre be established as a focus for forest research. This proposal was supported by forestry and forest research organisations as a way to focus efforts in key areas and develop a “critical mass” of research into commercial forestry. It is understood one proposal would have included State forestry and possibly some agriculture, CSIRO staff, several universities (Edith Cowan, Murdoch, Curtin and UWA) and possibly include some private company research with others supported by external funding. The proposal has not progressed at this time but must be seen as a valuable way to get the best value and outcomes from the resources available.

- ***Tasmania***

Tasmania has significant commercial native forest resources plus hardwood plantations and jointly owned (State-private) pine plantations.

Research is undertaken through the State organisation, CSIRO and the University of Tasmania and the CRC for Forestry has its headquarters in the State. Forestry Tasmania has a research group focusing on native forest and hardwood plantations. The group consists of 15 scientists with 13 technicians, two of whom are in field areas distant from Hobart. The group interacts with CSIRO and the University (4 of the scientists are from the University but are located at the State facility). The main areas of research are in nutrition, silviculture, hydrology and genetics. Work is undertaken in forest health and services are contracted to private companies. The programs are focused but the group is probably the minimum size to maintain viability in all key areas (that is, if staff are lost, so is an area of research or a function). Some research work is undertaken by the Forest Practices Board as part of its functions.

CSIRO has a small group within Tasmania, part of it falling within the Sustainable Ecosystems Division and cooperating with other groups in the area.

Significant research into forestry and forest products is undertaken at the University of Tasmania. The location of the CRC there and its inter-State interactions make numbers difficult to determine but it is estimated as more than 15 FTE in forestry plus a further 6 staff in forest products plus graduate students. The presence of the CRC provides greater direction, integration and interaction of graduate students than at many other universities.

Research is also undertaken by private companies other than the contributions to the CRC for Forestry and FWPA.

Overall, Forestry Tasmania has a focused research program covering issues in native forests and hardwood plantations undertaken in cooperation with CSIRO and the University of Tasmania.

- ***Discussion***

Overall, Australia invested about $100 million in forestry and forest products research in 2007/08. This research was undertaken by about 50 organisations or companies with an additional number of organisations providing funding. There were, more or less, 600 researchers and technicians involved in research in these organisations together with additional support staff and external contractors. The general impression is of substantial overall investment in forestry and forest products research but a significant proportion of the resources is fragmented with a consequent impact on output. While there are some structures (such as RPCC) which provide some coordination overall, each organisation determines its own research objectives, directions and levels of resources.

In terms of estimated effective full time research staff (excluding support staff), the numbers in 2007/08 in State, Commonwealth, University and Private organisations were approximately 247, 183, 182 and 129 researchers (scientists plus technicians) respectively. The numbers of staff in Universities were the most difficult category to estimate as there are mixtures of full and part term research staff and post graduate students at various stages in their programs.

- Research organisations and structures are a result of historical developments overlain with more recent re-structurings and changes. Considering a reference point of more than twenty years ago, forestry research was mainly undertaken by State organisations which had either forest research divisions and/ or significant forest products research capacity and by Divisions of CSIRO in both forestry and forest products. At that time, most forest resources were State-owned and much of the plantation expansion was Commonwealth-funded. With notable exceptions, there were only small research undertakings by private companies. The main Universities consistently undertaking research were Melbourne University and the Australian National University (ANU), and most Australian students were sourced from and partially supported by Government agencies and hence research was usually directed to the objectives of those agencies. There was significant coordination of research through the Research Working Groups (RWGs) and the Directors of the Research Committee to the then Standing Committee on Forestry. The main considerations of the RWGs were to identify and advise on deficiencies in research and possible consequences.

- In the intervening period, there have been significant changes in the structure of the forestry industry and they include the sale of State plantation resources and significant changes in accessibility to native forest resources. Many organisations, including their research divisions, have been re-structured and reduced in size and function, and direct linkages to industry have been modified. The number of Universities reporting some research involvement has increased greatly, but with some exceptions, research is not coordinated well from an industry perspective. [Possibly, the competitive funding requirements make cooperation difficult in some instances). The number of private companies (such as MIS companies) has increased significantly in plantation forestry and there has been a major shift in the species being planted and the locations of the planting efforts. Their cumulative research efforts have increased (directly or through CRC's). However, efforts in some areas appear to be fragmented and repetitive.

- A perception may be that the directions and strategies for the forest industry and related research may appear less clear than 20 years ago and it would appear that greater efforts are invested in non-production aspects of forestry research (for example, biodiversity, etc). The Research Priorities and Coordinating Committee (RPCC) is a coordinating and advisory body primarily representing Government Departments and has developed a research strategy (subsequently used as a framework for the FWPA strategy) where the focus is largely on policy and regulation rather than on commercial forestry (RPCC 2008).

- CSIRO is the most significant component of the forest research industry (both forestry and forest products) but it is no longer within a single Division in the CSIRO structure. This may allow resources and expertise to be derived from various sections of CSIRO to focus on forestry issues, however, there is also the risk of losing a forestry focus.

The analysis of expenditure on forestry and forest products research in 2007/08 indicates there is an increase over time since 1981, however, when this is considered in terms of a common base (A$ 1981) there has been a general decline. Recognising there are some variations in interpretation, approx. $100 million was spent on research-related areas in 2007/08 and approximately $85 million of this was directly spent on research. That is, about $5.58 was spent on every commercially managed hectare of forest or the equivalent of $3.90 for every cubic metre of wood removed from forests or about 6.0% of the value of logs harvested. There are no benchmarks to determine whether these estimates are high or low, but on face value there would appear to be a significant investment in research.

Funding for research is provided from various sources that have a number of different objectives and is expended by about 50 different organisations with differing sizes and structures, with in the order of a total of 600 researchers. How strategies and objectives are determined by each of these organisations has not been addressed nor has there been any attempt to consider how effective the expenditure has been in terms of research outcomes.

Estimates of the number of researchers indicate a steady decline since about 1990 in the Commonwealth and State Sectors, and increases occurring in the University and private Sectors. The increases in more recent times tend to be due to more organisations reporting research rather than an expansion of any particular research group. The expertise of each researcher has not been recorded, however, with regard to a decline, discussions with organisations indicate that some areas of research have been affected more than others (these areas are for example, forest health, forest silviculture, and hydrology). The reduction in research capacity is a concern but more so when capacity in some key areas is greatly diminished and risk is increased.

In an earlier analysis of forestry research in the United States, Giese (1988) reported a number of trends, such as the supply of new scientists for forestry research in the US declining for over 10 years (prior to 1987) as had general support for forestry research in financial terms. The decline was occurring despite an increasing long term need to understand ecosystem processes and economics associated with the use of forests. At that time, Giese concluded that the scientific community which traditionally had been available to deal with the issues as they arose, was being slowly but steadily dismantled. In the US Forest Service, the annual research budget (unadjusted for inflation) declined between 1977 and 1986 from US$ 129 million to US$ 100 million, and from 949 to 747 scientist-year equivalents. A comparable decline in federally funded expenditure for university forestry research occurred over the same period. In addition to actual resources, Giese (1988) identified the consequences of a deteriorating system of forestry research as:

- Loss of synergy that results from teams of diverse scientists working to solve large-scale and long-term problems.
- Knowledge gained through negative results or experiments, which is usually not published, and hence lost through cut-backs or retirements. The natural consequence is that in the future, experiments will be re-done.
- Forgoing of long-range benchmark projects, such as hydrological projects and the Hubbard Brook type ecosystem-level study, by providing funding for more fashionable research.
- Incapacity to address difficult emerging problems.
- Inability to identify and understand the cumulative long-term effects of the increasing demands for multiple use of forests.
- Lack of understanding of effects as part of a global economy and ecology.
- Inability of alternative disciplines (for example, agriculture) to answer specific forestry questions.

These issues are relevant to the declines being monitored currently in Australia.

Sutton (1986) addressed the issues of research structures and the stimuli for undertaking research by individual researchers in the three broad categories, namely basic, applied and developmental. Characteristics of basic research in forestry include longer term projects which are more widely applicable, and have higher risk and higher investment, but when successful, have the largest, longer term benefits. Also, such work is the most challenging and attractive to researchers. Alternatively, developmental research is generally shorter term, has low risk, is immediate, locally relevant, specific research and often is modifying or implementing previous research. Basic research is mainly focused in larger, structured, multidisciplinary organisations (related to facilities) whereas developmental is in smaller units with less available resources. Applied research falls somewhere between these descriptions. Larger organisations more probably have a balance of the various types of research. The changes in more recent times have led to a decline in the number of large facilities undertaking basic research. Much research is now undertaken in groups which can be described as at a minimum viable size. Any further decline means a loss in function or activity. This has been recognised by a number of organisations. In the case of the situation in Western Australia (WA), there have been proposals to develop a 'Forest Science Centre' which uses resources of multiple organisations under a common directorship, to accrue resources and expertise. It may be argued that the CRC structure had this approach as an objective but it appears there has been variable success while common direction has not always been successful.

Looking back across Australia, say for 10 years, there tended to be a balance of research with Commonwealth funding for CSIRO allowing basic research to be undertaken by CSIRO and in the larger facilities at the State level. Much of the research at the State level may have been considered to be applied research with some developmental research and as a broad generalisation. Private companies undertake some applied research but their research is largely developmental. Universities undertake applied research and this is mainly through PhD students. Decreases in the number of organisations and in resources and requirements for additional external funding generally require results in shorter time frames and with lower risks. Hence, basic research is reduced and there is greater emphasis on applied and developmental research, particularly using accumulated knowledge and information.

Essentially, forestry is a technically based industry which requires continual scientific inputs for development. It is long term by nature and much research requires results from a minimum period in order to be confident of the results, this period representing a significant proportion of the rotation length (e.g. one third to half a rotation length). That is, the length of many research programs will need to be for five to ten years as a minimum.

Forestry research needs to support the strategy and direction of the forestry industry. In the absence of a clear strategy, one approach is to ask the basic question of where would industry see itself (under optimum conditions) at some time in the future (say 10 or 20 years). Some outcomes will have no research applicability but it is direction that is required. If the answer can be provided now or in a short space of time. research is not required. Research of its nature has to look to the future. Analysis from a commercial forestry basis, rather than from a forest policy or regulatory viewpoint could include:

- A system of plantation development which has final production (per unit area) as a driver rather than the area planted. This would intensify productivity per unit area
- Forest industries, on a regional basis will be fossil-fuel user-neutral or there would be an excess of bio-energy. Forestry would consider solid and liquid bio-energy sources on a regional basis so that the industry fossil-fuel energy usage will be equal to or less than that from bio-energy (preferably from forestry sources).
- Key development in drier areas (including carbon) and systems to trade off water usage.
- Multiple species use (lower demands).
- Key sustainable indicators.
- Development of the use of summer low-flammability species (e.g. poplars) to increase protection.
- Development and application of forest type specific silviculture.
- Strong technical support for forest products certification.

Consideration has been given to the aim for a critical mass to enable a balance of basic, applied and developmental work to be undertaken together with the numbers and fragmented nature of the University system and private companies. One suggestion is to propose a national series of Forest Science Centres with a Scientist as Director and the staffing to include members of different organisations but located in central locations. The Centres would be coordinated and undertake a range of activities and each would focus on different specific areas, depending on location and the resource base. In many cases, this could involve the use of existing State facilities with additions of staff from CSIRO, private companies and Universities. One example is a focus on forestry in an extreme Mediterranean climate and including water use and selection of drier species for Western Australia, and another in South Australia where there could be a focus on radiata pine growth, water use and modelling. One objective would be to concentrate private company inputs and reduce overlaps. While such an approach would not match the directions in the present structure of CSIRO, the overall impact would provide more long term support for commercial forestry in Australia.

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