

## Expenditure on forest and forest products research in Australia 1981–1982 to 2001–2002

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### Summary

Expenditure on production-oriented forest and forest products research within Australia over a 12-month period in 2001–2002 was compared with a series of research expenditure reviews completed over the past 20 y to analyse changes and provide a historical perspective of investment patterns in research over that period. The expenditure in 2001–2002 on forest research and forest products research was \$50.51 million and \$19.73 million respectively, a total overall of \$70.24 million. The actual expenditure in 1981–1982 was \$24.32 million and \$14.30 million respectively, but when expenditure over this 20-y period was adjusted for inflation by the Consumer Price Index there were significant and continual declines from \$60.59 million and \$35.63 million respectively in 1981–1982. Although the study in 2001–2002 focused on research expenditure, costs of technical services and research management were also compiled.

Considering the total forest research expenditure from 1981–1982 to 2001–2002 by the main sectors (Commonwealth, companies, State agencies, universities), the Commonwealth proportion increased from about 40.9% to 45.2% as a result of increases in expenditure through the Cooperative Research Centres and the Forest and Wood Products Research and Development Corporation, and the university proportion increased from 4.4% to 6.7%. The proportional input to research by organisations with the responsibility for managing forests, that is, State agencies and companies, reduced from 54.7% to 48.1%. There were also changes from 1981–1982 to 2001–2002 in the relative emphasis on different categories of research.

*Keywords:* research expenditure; plantations; native forests; forest products; environment; surveys

### Introduction

Expenditure on research is an investment in the future of an industry. However, the level of expenditure on research which is appropriate or optimum for any industry is difficult to determine and the level will change over time as the nature and structure of the industry itself changes. The forest and forest products industries are technically based, and research is essential for continued improvements in forest management and utilisation. The present report is an analysis of the estimates of expenditure on forest and forest products research within Australia in

2001–2002 in comparison with levels in previous years. While there are no universal criteria for determining or guiding appropriate levels of expenditure, regular reviews of expenditure allow analyses to be made on trends together with changes in the sectors contributing to the expenditure.

In an analysis of forest research in the United States of America (USA), Giese (1988) reported on a number of trends which included the supply of new scientists for forest research in the USA which had been declining for more than 10 y (prior to 1987) as had general support for forest research in financial terms. This decline was occurring despite an increasing long-term need to understand the ecosystem processes and economics associated with the use of forests. At that time, Giese (1988) 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 the number of scientists declined from 949 to 747. A comparable decline in federally funded expenditure for university forest research occurred over the same time. This information was updated by Guldin (2002).

In addition to the actual resources, Giese (1988) identified the consequences of a deteriorating system of forest research as:

- Loss of synergy that results from teams of diverse scientists working to solve large-scale and long-term problems.
- Knowledge that has been gained through negative results or experiments and usually not yet published, being lost through cut-backs or retirements (that is, loss of corporate knowledge). The natural consequence is that, in the future, experiments will be re-done.
- Foregoing of long-range benchmark projects, such as hydrological projects and the Hubbard Brook type ecosystem-level study, by re-directing funding to more fashionable research.
- Incapacity to address difficult emerging problems.
- Inability to identify and understand the cumulative long-term effects of 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.

The patterns and effects of such changes are relevant to Australia, especially in relation to the changes in structure and systems within the forest based industry.

The present analysis is a review of research expenditure in 2001–2002 on forests and forest products and an assessment of the trends over the past 20 y by reference to previous studies (Briefing by Lionel Wood, Secretary, Standing Committee of Forestry, to H. Booth and J. Quick for their 1987 study, hereafter ‘SCF briefing’; Quick and Booth 1987; Lambert and Turner 1992; Turner and Lambert 1997) and others which are specifically identified. Reporting by ABS (2003a,b) is relevant to the present analysis, but unfortunately forest research and forest products research were not separately identified, the broad categories of research were not considered and the analyses took a much broader view of research, as for example, surveys were not separated from research.

## Methods

The two broad areas of interest are expenditure on forest research and forest products research. Forest research was defined as scientific investigation into fields associated with the establishment, management, protection, improvement and environmental effects of commercial native or planted forests. Research undertaken on areas managed specifically for conservation (for example, forests within national parks) was not included. Forest products research in its broadest sense involves research into value adding of wood. Work on final product development (for example, furniture production), production and test runs in mills, environmental monitoring, or quality control assessment were not included. Research was divided into the categories (based on the initial analysis of Quick and Booth 1987) of native and exotic species plantations (primarily *Pinus* spp.), native forests, and environment which was primarily soil erosion and hydrology research spanning more than one forest management type. Survey work included field assessments such as fauna and flora surveys. Costs of monitoring, where available, such as on forest growth, health, nutrition and/or biodiversity were not included in research, but were tracked separately and reported within the survey category. Costs of research management (forest and forest products) were tracked as a separate component.

The information was obtained from direct contact with organisations (personal, telephone, mail, email) using a standard set of questions and was supported by documentation such as annual reports<sup>1</sup> where available. The discussions with individual

organisations were important to ensure consistency, since that which is considered to be routine assessment by one organisation may be identified as research by another.

Annual expenditure on research activities in 2001–2002 by organisations directly undertaking research constituted the primary data (a list of the contacted organisations is provided in the Acknowledgements). That is, the focus was on expenditure on research undertaken, as opposed to the organisations providing funds for research. Where multiple organisations were involved in funding a research program, the data from each source were tracked separately to avoid double counting. Individual organisations have not been identified and all data have been pooled. The Cooperative Research Centres (CRCs), the Forest and Wood Products Research and Development Corporation (FWPRDC) and CSIRO were accounted for within the Commonwealth category, with care being taken to ensure there was no double counting.

The primary focus was on investment in research but, where available, information on technical services, administration and management of research was also compiled as closely as possible to match the original definitions of Quick and Booth (1987). The sum of the costs of these components has been reported under the category of management. Technical services were defined as scientific services including laboratory, computing services supporting research, and library services, but did not include an area such as information technology services provided in general to the organisation. All such services may be provided by a research or technical division within an organisation and be identified as a cost of providing technical services, but for the purposes of this analysis they were reported separately from research. The reported expenditure was that provided by the contacted organisations and in the case of staff, included salaries and staff overheads. Costs of accommodation, higher-level company management and that which may be defined as central services, were not included.

The data for 2001–2002 together with information from previous assessments of research expenditure, were compiled within Excel spreadsheets. Analyses of the data included changes with time, changes in expenditure according to sector, changes in the Consumer Price Index (CPI) over time, and changes in expenditure in terms of the forest estate or quantity of timber harvested. In calculations on native forest plantations, the areas of *Araucaria* spp. were included.

## Results

### Forest research

The estimates of expenditure on forest research, together with trend information for all the study periods according to sector, are presented in Table 1. The annual changes are also presented together with the overall estimate of costs of research management as an additional component.

The value of forest research (unadjusted for CPI) has increased from \$24.32 million per year in 1981–1982 to \$50.51 million in 2001–2002. Between 1981–1982 and 1985–1986, the annual average rate of increase in expenditure was 6.9%, but between 1994–1995 and 2001–2002, this had declined to 1.3% (Table 1).

<sup>1</sup> These reports included:

Cooperative Research Centre (CRC) for Catchment Hydrology Annual Report (2001–2002) 120 pp.; CRC for Functional Communication, Annual Report (2001–2002) (2 volumes); CRC for Greenhouse Accounting Annual Report (2001–2002) 71 pp.; CRC for Innovative Wood Manufacturing Annual Report (2001–2002) 57 pp.; CRC for Sustainable Production Forestry Annual Report (2001–2002) 128 pp.; CRC for Plant-based Management of Dryland Salinity Annual Report (2001–2002) 88 pp.; Department of Conservation and Land Management, Western Australia. Science Division, Research Activity Report (July 2001–June 2002); Forest and Wood Products Research and Development Corporation (2001–2002); Division of Forest Development, Forestry Tasmania, Annual Report (2001–2002) 70 pp.

**Table 1.** Annual expenditure on forest research (million \$ unadjusted for inflation) between 1981–1982 and 2001–2002

Sector	1981–1982 <sup>a</sup>		1985–1986 <sup>b</sup>		1989–1990 <sup>c</sup>		1994–1995 <sup>d</sup>		2001–2002 <sup>e</sup>	
	(\$)	(%)	(\$)	(%)	(\$)	(%)	(\$)	(%)	(\$)	(%)
Commonwealth	10.00	41.1	12.11	38.9	14.91	37.9	19.52	42.2	22.84	45.2
Companies	2.02	8.3	2.71	8.7	4.51	11.5	3.82	8.3	3.5	6.9
State agencies	11.24	46.4	14.35	46.1	17.62	44.9	20.25	43.8	20.8	41.2
Universities	1.07	4.4	1.94	6.2	2.22	5.7	2.65	5.7	3.37	6.7
Total	24.32		31.11		39.26		46.24		50.51	
Annual change (%) <sup>f</sup>		6.9		6.6		3.6		1.3		
Management <sup>g</sup>	5.37	22	7.47	24	10.6	27	12.95	28	15.87	31

<sup>a</sup>SCF briefing; <sup>b</sup>Quick and Booth (1987); <sup>c</sup>Lambert and Turner (1992); <sup>d</sup>Turner and Lambert (1997); <sup>e</sup>Present study; <sup>f</sup>Annual change between two periods;

<sup>g</sup>Administration and management of research. This expenditure was not included in the total of forest research but the percentage is expressed as an indicative percentage of the total expenditure.

**Table 2.** Broad categories of annual forest research expenditure (million \$ unadjusted for inflation) between 1981–1982 and 2001–2002

Sector	1981–1982 <sup>a</sup>		1985–1986 <sup>b</sup>		1989–1990 <sup>c</sup>		1994–1995 <sup>d</sup>		2001–2002 <sup>e</sup>	
	(\$)	(%)	(\$)	(%)	(\$)	(%)	(\$)	(%)	(\$)	(%)
Exotic species plantations	10.42	42.8	12.97	41.7	17.56	44.7	19.05	41.2	17.68	35.0
Native species plantations	0.61	2.5	1.04	3.4	1.95	5.0	5.61	12.1	15.86	31.4
Native forests	10.16	41.8	12.44	40.0	13.95	35.5	15.87	34.3	12.75	25.2
Environment	3.14	12.9	4.66	14.9	5.80	14.8	5.71	2.3	4.22	8.4
Total	24.32		31.11		39.26		46.24		50.51	
Surveys <sup>f</sup> (including monitoring)	0.55	2.3	0.91	2.9	1.96	5.0	3.26	7.1	5.41	10.7

<sup>a</sup>SCF briefing; <sup>b</sup>Quick and Booth (1987); <sup>c</sup>Lambert and Turner (1992); <sup>d</sup>Turner and Lambert (1997); <sup>e</sup>Present study; <sup>f</sup>Surveys have not been included in the total of forest research but the percentage is expressed as an indicative percentage of the total expenditure.

The proportion of expenditure varied between sectors over the period of the study. The Commonwealth component was about 41.1% in 1981–1982, declining in the following two periods, then increasing to 45.2% in 2001–2002, the increases largely being a result of inputs to CRCs and the FWPRDC. Expenditure by universities rose from 4.4% in the initial period to about 6.7% of total expenditure in 2001–2002. The expenditure by state agencies and companies has generally declined over the period of the studies. Initially, the combined estimate was 54.7% and is now 48.1%. These two latter sectors together represent the major entities responsible for the management of forests.

There was an increase in the cost of research administration and management from 22% to 31% over the 20-y period (Table 4). This component consistently increased over the 20-y period and is attributed to non-research managers (for example, business managers, IT managers) and research coordinators being appointed within organisations, many of whom coordinate and direct research rather than directly undertake research.

The broad categories of forest research expenditure are presented in Table 2. Research in native forests (primarily silvicultural research) has declined from 41.8% of total expenditure in the first period (1981–1982) to 25.2% in the most recent estimate. Much of the environmental research in 1981–1982 was undertaken in native forests and the combination of this with research in native forests represented 54.7% of the research in 1981–1982, but had declined to 33.6% in the most recent period. Research on exotic species plantations was an area of strong

interest between 1981–1982 and 1994–1995, between 41.2% and 44.7%, but had declined to 35.0% in the most recent period. The category with a consistent and very significant increase in expenditure has been research into plantations of native species (hardwood and *Araucaria*), increasing from 2.5% in the first period to 31.4% in the 2001–2002 assessment year. Of note also is the increase in surveys (including monitoring) from the equivalent of 2.3% of research expenditure in the first period to 10.7% in the final period. Much of the decline in research in native forests and environment appears to have been replaced by survey work and research on native species plantations.

Expenditure in the broad research areas was adjusted according to the CPI to provide a comparison in 2002 dollars (Table 3). Total adjusted expenditure in 1981–1982 was \$60.58 million and there has been a steady decline to \$50.51 million in 2001–2002, this representing about a 20% decrease or about 1% each year. In adjusted dollars, the main area of increase over the study period has been in native species plantations. Expenditure on surveys has also increased consistently.

Although not reported here, the 'CPI adjusted' expenditure was assessed according to sector. The largest change over the period was in company research, which has declined in adjusted terms by 30.6% or about 1.5% each year. Adjusted expenditure by State agencies has declined by 21.9% or about 1% each year, and for the Commonwealth there was a total decline of 8.4% or 0.4% each year. University research had increased by about 27% or 1.3% each year. This latter increase reflects inputs from CRCs

**Table 3.** Broad categories of annual forest research expenditure (million \$ adjusted for inflation to 2002 dollars) between 1981–1982 and 2001–2002

Sector	1981–1982 <sup>a</sup>	1985–1986 <sup>b</sup>	1989–1990 <sup>c</sup>	1994–1995 <sup>d</sup>	2001–2002 <sup>e</sup>
Exotic species plantations	25.95	23.99	23.88	22.67	17.68
Native species plantations	1.51	1.93	2.65	6.68	15.86
Native forests	25.31	23.02	18.97	13.89	12.75
Environment	7.81	8.61	7.89	6.79	4.22
Total	60.59	57.55	53.39	55.03	50.51
Surveys (including monitoring)	1.38	1.68	2.64	3.69	5.41

<sup>a</sup>SCF briefing; <sup>b</sup>Quick and Booth (1987); <sup>c</sup>Lambert and Turner (1992); <sup>d</sup>Turner and Lambert (1997); <sup>e</sup>Present study

**Table 4.** Total annual expenditure (million \$ unadjusted for inflation) on research, surveys and research management (including costs of administration and management) in forestry

Period	Total expenditure on research, surveys and management (\$)	Proportion of research (%)
1981–1982	30.25	80
1985–1986	39.48	79
1989–1990	51.82	76
1994–1995	62.44	74
2001–2002	71.79	70

and more universities being involved in some aspects of forest research.

Expenditure on forest research per managed hectare was analysed within each category (Table 5). The areas were compiled and reported by ABARE (2002) but areas of farm forestry plantations were not included as they were only small. The areas in each individual category of exotic species plantations, native species plantations, and production native forests (that is, those forests available for multiple use management including timber production) were collated and divided into the expenditure for that category to give an estimate of research expenditure per hectare.

The actual expenditure (unadjusted for inflation) on all categories increased from 1981–1982 to 1994–1995 and then declined in 2001–2002. Expenditure on exotic species plantations increased from \$14.2 ha<sup>-1</sup> in 1981–1982 to \$22.2 ha<sup>-1</sup> in 1994–1995 but decreased to \$18.76 ha<sup>-1</sup> in 2001–2002. Actual expenditure on native species plantations increased from \$7.0 ha<sup>-1</sup> in 1981–1982 to \$27.5 ha<sup>-1</sup> in 1994–1995 and decreased to \$23.2 ha<sup>-1</sup> in 2001–2002. There was a significant area of native species plantations in 1981–1982 as in that period the *Araucaria* plantations were included in addition to *Eucalyptus*. In terms of expenditure (adjusted for the CPI), there was a decline in all categories from 1981–1982 to 2001–2002 with the exception of research on native species plantations for which there was an increasing trend to 1994–1995, but a decrease in 2001–2002 which is attributed to the relatively large extension of the plantation estate in the past decade. Expenditure on research in native forests was in the range of \$0.6 ha<sup>-1</sup> to \$1.0 ha<sup>-1</sup> and when environment was included, this increased to \$2.3 ha<sup>-1</sup>.

### Forest products research

Analysis of expenditure (unadjusted for inflation) on forest products research (Table 6) indicated that the total had increased from \$14.30 million in 1981–1982 to \$19.73 million in 2001–2002. The total expenditure (adjusted for the CPI) was \$35.63 million in 1981–1982 and this decreased to \$19.73 million in 2001–2002. Effectively this was a decrease of 44.6%. In 1981–1982, companies undertook the largest proportion of research (49.7%) followed by the Commonwealth sector (38.2%). By 2001–2002, the Commonwealth sector represented 46.3% of expenditure and companies represented 34.6%.

The expenditure on forest products research was assessed in relation to the quantity of wood harvested (\$ m<sup>-3</sup>). In terms of direct expenditure (unadjusted for inflation), there was limited variation over the period of study (from \$3.70 m<sup>-3</sup> in 1981–1982 to \$3.26 m<sup>-3</sup> in 2001–2002). In terms of expenditure adjusted for the CPI, there has been a decline in expenditure from \$9.23 m<sup>-3</sup> in 1981–1982 to \$3.26 m<sup>-3</sup> in 2001–2002.

### Outputs and costs of scientific publications

The level of output from research is difficult to assess in a standard manner across a range of organisations. One method is to assess the listings of scientific publications. In this regard, the scientific publications listed in annual reports by CSIRO Divisions, State agencies, universities and some companies have been reviewed. When annual reports were not available, publication lists were obtained from librarians or publicity staff. The scientific publications in each specified year were categorised as forest-based or forest products-based and divided into refereed (those in refereed scientific journals) and 'in-house' (these being reports published by the organisation, or in conference proceedings, and some unrefereed journals). Company or client reports, and unpublished reports with limited circulation, were not included. Care was taken to not double count joint authorship across organisations. The publications were not formally divided into fields of study. The approach did not cover the total number of publications by organisations in any year but was a standard sampling of defined publications. The information is presented in Table 7.

In general, the total number of publications on forest research increased in the period from 1982 to 2002. Using the data for total annual expenditure on forest or forest products research,

**Table 5.** Annual expenditure in terms of dollars per managed hectare for each expenditure category. Both actual (based on dollars in the time period) and adjusted (adjusted for inflation according to the CPI) estimates are shown.

Sector	Measure	1981–1982 <sup>a</sup>	1985–1986 <sup>b</sup>	1989–1990 <sup>c</sup>	1994–1995 <sup>d</sup>	2001–2002 <sup>e</sup>
Exotic species plantations	Actual	14.22	16.49	21.44	22.19	18.76
	CPI adjusted	35.41	30.50	29.15	27.51	18.76
Native species plantations	Actual	6.98	12.09	15.11	27.51	23.20
	CPI adjusted	17.38	22.37	20.55	32.74	23.20
Native forests	Actual	0.56	0.68	0.80	0.96	0.77
	CPI adjusted	1.39	1.26	1.09	1.15	0.77
Environment	Actual	0.73	0.94	1.14	1.31	1.02
	CPI adjusted	1.82	1.73	1.55	1.56	1.02
Surveys (including monitoring)	Actual	0.03	0.05	0.11	0.19	0.33
	CPI adjusted	0.08	0.09	0.15	0.24	0.33

<sup>a</sup>SCF briefing; <sup>b</sup>Quick and Booth (1987); <sup>c</sup>Lambert and Turner (1992); <sup>d</sup>Turner and Lambert (1997); <sup>e</sup>Present study

**Table 6.** Summary of annual expenditure on forest products research (million \$ unadjusted for inflation) in selected years between 1981–1982 and 2001–2002, totals adjusted for changes in Consumer Price Index (CPI) and expenditure per unit volume harvested

Sector	1981–1982 <sup>a</sup>		1985–1986 <sup>b</sup>		1989–1990 <sup>c</sup>		1994–1995 <sup>d</sup>		2001–2002 <sup>e</sup>	
	(\$)	(%)	(\$)	(%)	(\$)	(%)	(\$)	(%)	(\$)	(%)
Commonwealth	5.46	38.2	5.85	38.5	6.18	34.9	9.47	47.2	9.13	46.3
Companies	7.11	49.7	7.39	48.6	9.11	51.5	7.85	39.0	6.82	34.6
State agencies	1.27	8.9	1.41	9.3	1.77	10.0	2.16	10.8	1.41	7.1
Universities	0.46	3.2	0.56	3.7	0.63	3.6	0.59	2.9	2.37	12.0
Total	14.30		15.21		17.69		20.07		19.73	
Annual change (%) <sup>f</sup>		1.6		4.1		2.7		-0.7		
Total (adjusted for CPI)	35.63		28.13		24.06		23.88		19.73	
Exp. (\$) m <sup>-3</sup> harvested (unadjusted)	3.70		3.63		3.71		3.16		3.26	
Exp. (\$) m <sup>-3</sup> harvested (adjusted for CPI)	9.23		7.22		5.04		3.76		3.26	

<sup>a</sup>SCF briefing; <sup>b</sup>Quick and Booth (1987); <sup>c</sup>Lambert and Turner (1992); <sup>d</sup>Turner and Lambert (1997); <sup>e</sup>Present study;

<sup>f</sup>Annual change between two successive periods

the cost per publication was calculated<sup>2</sup>. This indicates the investment in research to produce a publication (essentially, the total of the average amount of field or experimental work, analyses, production, etc.), and in the case of a forest research publication it was about \$222 830 in 2002. The number of publications on forest products research decreased in total from 82 y<sup>-1</sup> in 1981–1982 to 62 y<sup>-1</sup> in 2001–2002. Using an evaluation similar to that for forest research, the investment in research for a publication in forest products equated to about \$318 220.

## Discussion

Analyses of expenditure on forest and forest products research have been undertaken over the period from 1981–1982 to 2001–2002. The 1981–1982 estimates were based on submissions to the then Standing Committee on Forestry (SCF briefing) and formed the basis for a more comprehensive analysis (Quick and Booth 1987), a major objective of which was to identify categories of research. The definition of research is always subject to some interpretation, but the objective has been to assess the actual effort expended on research excluding surveys and assessments.

Forest research over the period from 1981–1982 to 2001–2002 increased (in unadjusted dollars) from a total of \$24.32 million y<sup>-1</sup> to \$50.51 million y<sup>-1</sup>. During that period, there has been an

<sup>2</sup>Strictly, publications in any one year reflect work (and expenditure) in previous years.

**Table 7.** Estimated number of scientific publications produced by the main forest research organisations in Australia in selected years together with the index of cost per publication based on the total annual expenditure on research

Category	1982	1986	1990	1995	2002
<i>Forestry</i>					
Refereed	117	108	127	155	142
Unrefereed	71	47	55	77	85
Total	188	155	182	232	227
Cost per publication (\$)	129 372	200 677	215 709	199 319	221 826
<i>Forest products</i>					
Refereed	45	44	56	36	37
Unrefereed	37	48	31	29	25
Total	82	92	87	65	62
Cost per publication (CPI indexed) (\$)	174 427	165 283	203 333	308 769	318 221

increase in the expenditure on forest surveys and also on research management. The Australian Bureau of Statistics (2003a) reported that the total expenditure in Australia on applied research in 2000–2001 in the category of ‘agricultural, veterinary and environmental sciences’ was \$587.8 million. By comparison, the total expenditure of \$50.51 million on forest research was 8.6% of that total. The total expenditure on research surveys and research management (including costs of administration and management) (Table 7) indicates that a smaller proportion of the funds which are available for research and related services, is being spent on actual research.

### Research context and emphasis

The CRCs now undertake a significant proportion of research, and the proportion undertaken by universities has increased. However, the emphasis in CRCs and universities is short term (1–7 y). Although state agencies and CSIRO undertake longer-term research, this component has declined. Few companies are undertaking significant levels of research in addition to that undertaken through CRCs, and hence the Boards of CRCs are now influencing the directions of that research. The FWPRDC allocated \$7.1 million for research on forestry and forest products in 2001–2002; this was 10.1% of total forest and forest products expenditure (\$70.235 million). When the cooperators’ components were included, the FWPRDC influences more than 20% of annual research (total of forest and forest products) expenditure.

During the period of the study (from 1981 to 2002), a number of changes have taken place within the forest industry, and these have directly affected the research effort and the assets to which the research is applied. The changes include:

- continuing expansion of softwood and hardwood plantations
- a reduced rate of planting of exotic conifers but an increased emphasis on native hardwood plantations. This has been accompanied by changes in the available land planting base, including changes from primarily planting on previous forest sites to primarily planting on pasture sites and second-rotation areas (Turner 1998).
- ownership of some plantations changing from the states to companies

- plantation companies taking a greater role in the establishment of plantations, especially with regard to hardwood plantations
- the establishment of CRCs that incorporate the expertise and resources of CSIRO, universities, companies and other research organisations. This has led to additional Commonwealth funds being made available (beyond direct funding), but it may have also been accompanied by an overall decrease in expenditure by companies.
- the demise of some organisations previously supporting research, such as the Timber Advisory Council in NSW
- the establishment of the FWPRDC, resulting in increased inputs from government to match funds levied from industry. The levy paid by companies may be the ceiling for research expenditure by many companies.
- the number of universities with interests in forest and forest products research increasing and their emphases being different
- many forest research organisations having been re-structured. This has usually led to overall reductions in staff and expertise.
- greater competition from alternative products
- processes such as the development of Regional Forest Agreements having led to resources being moved from research to survey, monitoring and assessment
- signing of the Montreal Process on sustainability, and consequent requirements for research and monitoring changing research directions
- a move to certification, with increased emphasis on survey and monitoring activities
- greater use of technology to obtain information and increased reliance on the information technology sector.

The changes that have taken place within the forest industry historically represent rapid changes in the nature of the resource and the requirements for management, and this suggests an increasing requirement for research to ensure continued improvement in all aspects of the industry. However, expenditure — especially by the various forest management organisations — is in fact declining in real terms. Overall, there appears to be a

**Table 8.** Resources (expenditure in US\$ unadjusted for inflation) applied by the US Forest Service to forest and forest products research (Guldin 2002). Appropriations do not include administration and management. The scientific publications were listed as accomplishments and covered all categories of research.

	Year				
	1982	1985	1990	1995	2000
Appropriation (US\$ million)					
Actual	112.1	121.7	144.7	197.3	202.5
Annual change (%)		2.8	3.8	7.3	0.53
Actual adj. to constant baseline (1985)	126.8	121.7	121.1	140.4	127.1
Annual change (%)		-1.3	-0.1	3.2	-1.89
Number of researchers					
Forestry		922	695	582	534
Forest Products		63	31	25	15
Total		985	726	607	549
Number of publications	1 909	2 299	2 165	3 021	
Publications per researcher		2.33	2.98	4.98	
Publication value (\$)	58 722	52 936	66 836	65 310	
Managed area (million ha)	292	292	293	293	295
Research US\$ ha <sup>-1</sup> (actual)	0.38	0.42	0.49	0.67	0.69
Research US\$ ha <sup>-1</sup> (CPI adjusted)	0.43	0.42	0.41	0.48	0.43

lower recognition of the importance of investing in continued research in forests and forest industries. Development of CRCs has moved the responsibility of research from forest growers and processors to a third party.

Sutton (1986), from a forest scientist's perspective, recognised that there are three forms of research orientation. He reported that the most likely source of initiation for problem, service and innovative research, was from management, management or scientist, and scientist respectively, and the level of management acceptance was in the same order:

- Problem research (Research into relatively easily-defined problems)
- Service research (Research designed to help management do their job better)
- Innovative research (Research into new ways and systems).

He indicated that the highest level of risk is in innovative research, but this also has the potential for greatest returns. It appears from the 2000–2001 data that there has been a shift from significant interest in innovative research to a preponderance of 'problem oriented research' with low risk and modest potential returns.

Expenditure on forest products research in 2001–2002 was estimated as \$19.73 million, and when management overheads were included, the total was about \$24.30 million. This is comparable with the labour costs of \$25.29 million reported by the Australian Bureau of Statistics (ABS 2003b). However, that report also included a further \$52.86 million which is considered to be related to mill runs and related material costs, and these were specifically not included in the current estimates.

General estimates of research expenditure in New Zealand in 2001–2002 (direct expenditure not adjusted for inflation) were obtained from the New Zealand Forest Industries Council (2002) for the wood-fibre based research, excluding market research,

undertaken by private and government funding sources. The combined estimate (industry plus government) was about NZ\$62.3 million of which NZ\$34.8 million (56%) was from the industry. This industry component has increased over the last three years, although not to the level in 1997–1998. About NZ\$33.6 million was spent on post-harvest forest products research, and this equated to about NZ\$1.56 m<sup>-3</sup> harvested. This figure has been declining since the previous surveys (Lambert and Turner 1992; Turner and Lambert 1997) from NZ\$2.50 m<sup>-3</sup> in 1989–1990 and NZ\$1.98 m<sup>-3</sup> in 1994–1995. A total of NZ\$28.65 million was spent in 2001–2002 on tree improvement and management of forests (including indigenous forests). When research expenditure on indigenous forests was separated out, about NZ\$17.64 ha<sup>-1</sup> was spent on planted forests. This is comparable with Australian expenditure of A\$18.76 ha<sup>-1</sup> on exotic plantations but lower than the A\$23.20 ha<sup>-1</sup> on native species plantations.

The US Forest Service regularly monitors and reports on the resources it applies to research (Table 8).

The analysis by the US Forest Service did not include research resources from other organisations such as companies and universities. In the period 1982–2000, the actual research appropriation increased by 80% to more than US\$200 million, while in terms of a constant baseline (1985) the increase was 0.2% overall. From 1985 to 2000, the number of research staff declined by 44% and there were additional re-adjustments within the staff categories. For example, the number of foresters declined from 350 in 1985 to 140 in 2000, while the number of ecologists increased from 9 to 55 in the same period. The data indicate that the number of scientific publications by the US Forest Service (comparable with the categories used for assessing publication outputs in Australia) increased from 1909 in 1982 to 3021 in 1995, representing an increase in output per researcher from about 2.33 publications in 1985 to 4.98 in 1995. The input to research per managed hectare of forest in actual terms increased from

US\$0.38 ha<sup>-1</sup> in 1982 to US\$0.69 ha<sup>-1</sup> in 2000, but there was no change when the expenditure was adjusted for inflation.

The data for the US Forest Service indicate a decline in resources for research which parallels the situation in Australia. Simultaneously, there has been a shift in emphasis in the discipline areas. The reported costs of research administration and management in USA have declined from the equivalent of 10.0% of research costs in 1982 to 6% equivalent in 2000, while in Australia the reverse is the situation. Considering the output of publications in relation to research expenditure, the cost per publication was about US\$65 310, while in Australia the expenditure was four times this in relative dollar terms. There are some difficulties in using the number of publications produced and the costs of publications as a productivity index, especially for comparisons of organisations, but it does provide one basis for analysis.

Expenditure on forest research in Australia is declining due to restructuring of traditional forest management organisations (previously mainly government agencies) and increased involvement of companies as forest managers.

Whilst CRCs and the FWPRDC have been highly effective in providing some relatively long-term research funding, it is clear that additional measures need to be urgently explored to maintain research on forest and forest products at a level that ensures that the industry can survive in what is becoming a highly competitive and internationally exposed economic sector.

## Conclusions

- Expenditure on forest research over the past 20 y has increased (unadjusted for inflation) from \$24.41 million to \$50.51 million. When considered in terms of CPI-adjusted expenditure, resources applied to forest research have declined between 1981–1982 and 2000–2001.
- The distribution of research expenditure across research categories has changed, with a greater emphasis in recent years on native species plantations. Resources for surveys (including monitoring) have increased at the expense of those for research.
- A larger proportion of overall expenditure has been devoted in recent years to research administration and management. When the total expenditure on research, surveys and their related management is considered, a lower proportion has been expended on scientific research.
- The distribution of expenditure by organisations undertaking research (Commonwealth, state agencies, companies, universities) has changed, with a lower proportion of expenditure being undertaken by state agencies and companies. There is an indication that for many companies, research investment is largely limited to that undertaken by CRCs and projects sponsored by the FWPRDC. This may be interpreted as the private sector relying on its levies and CRC contributions to support R&D.
- Forest products research expenditure was \$19.73 million in 2001–2002, an increase in unadjusted terms from \$14.30 million in 1982. However, in CPI-adjusted terms, there has been about a 40% decrease over the period. The expenditure

on research per harvested cubic metre of timber decreased from \$3.70 m<sup>-3</sup> to \$3.26 m<sup>-3</sup> over the period and declined much more in CPI-adjusted terms.

- Expenditure by the FWPRDC was \$7.1 million in 2001–2002 and this represented about 10% of total expenditure on forest and forest products research in Australia. When leverage was considered, FWPRDC is providing its stakeholders input to more than 20% of forest industries research in Australia.
- Some categories of research have become concentrated in specific organisations (for example in CRCs) and there appears to have been a shift to categories with low risk (and relatively small potential return), such as surveys and support for programs like RFA assessments. The support for innovative research has declined.
- There is no objective and proven method to establish the level of research that should be undertaken at state and national levels. However, we believe the results from the present survey, when viewed in both absolute and historical terms, sound alarm bells for the forest industry. There is little doubt that the industry is rapidly being exposed to increased scrutiny in terms of its sustainability, competition from substitutes, the role of trade, and the effects of improvements in technology. The underpinning science will be fundamental to such important considerations and to future industry development. The level of funding available to CRCs and FWPRDC (and kindred Research and Development Corporations, for example, Rural Industries Research and Development Corporation, Land and Water Research Development Corporation), will provide a strategic base but must not be solely relied upon to ensure the industry reaches its full potential from state, national and global perspectives.

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