Indicator 6.2b: Investment in research, development, extension and use of new and improved technologies (2024)

This indicator monitors the investment in, and adoption of, new or improved technologies in forest management and in forest-based industries. It also quantifies the level of research and development. Significant investment in research, development and new technologies result in continual improvements to forest management practices.

Definitions

Research and development: Creative and systematic work undertaken in order to increase the stock of knowledge - including knowledge of humankind, culture and society – and to devise new applications of available knowledge (as defined by the Organisation for Economic Co-operation and Development).

Forest and wood products subsectors: Derived from the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 industry subdivision classifications.

Key points

- Investment in research and development activities (R&D) can lead to improvement in forest management practices, and to new technologies for commercial adoption.
- Total R&D business expenditure in the forest and wood products sector decreased from $164 million in 2005-06 to $102 million in 2017-18 (the latest year of complete data).

Business research and development expenditure

Total research and development (R&D) business expenditure in the forest and wood products sector decreased from $164.1 million in 2005-06 to $101.9 million in 2017-18 (Table 6.2b-1), a decline of 53% when adjusted for inflation to 2019-20 values (ABS 2023). These data are published biennially by the Australian Bureau of Statistics, with only partial data available for 2019-20, and fewer data with poorer reliability available for 2021-22.

Forest-sector business R&D expenditure declined as a proportion of total business R&D expenditure in Australia from 1.57% in 2005-06 to 0.46% in 2013-14, increasing slightly to 0.58% in 2017-18; this increase was driven largely by increases in R&D expenditure on wood product manufacturing (ABS 2023).

Table 6.2b-1: Business research and development expenditure in the forest and wood products sector

Subsector	Business R&D expenditure ($ million)									
	2005-06	2006-07	2007-08	2008-09	2009-10	2011-12	2013-14	2015-16	2017-18	2019-20
Forestry and logging	15.6	20.1	22	26	37.6	25.8	21.8	12.9	10.3	9.4
Wood product manufacturing	76.3	55.2	51.3	57.1	57.5	38.3	20.8	na	41	55.1
Pulp, paper and converted paper product manufacturing	72.2	70.7	71.1	53.8	na	48.2	43.3	70.1	50.6	na
Total research expenditure in forestry and wood products	**164.1**	**146**	**144.4**	**136.9**	**na**	**112.3**	**85.9**	**na**	**101.9**	**na**
Total business R&D expenditure in Australia	**10,434**	**12,639**	**15,047**	**17,291**	**16,760**	**18,323**	**18,849**	**16,659**	**17,437**	**18,171**
Proportion of total business R&D expenditure that is forest and wood products expenditure	1.57%	1.16%	0.96%	0.79%	na	0.61%	0.46%	na	0.58%	na

na, not available. Totals are not shown where data are incomplete. All values in this table reported by the Australian Bureau of Statistics have a relative standard error of 25-50% and should be used with caution. Data for 2021-22 not shown due to poor availability or poor reliability of available subsector data.

Source: (ABS 2023).

Click here for a Microsoft Excel workbook of the data for Table 6.2b-1.

Business R&D expenditure is also reported across the three forest and wood products subsectors of the forest and wood products sector (Table 6.2b-1). Business R&D expenditure in:

- the **forestry and logging subsector** decreased from $15.6 million in 2005-06 (after rising to $37.6 million in 2009-10) to $9.4 million in 2019-20, a decline of 57% when adjusted for inflation to 2019-20 values. In this subsector R&D may focus on ways to improve wood production and harvesting of wood products, or on identifying new markets for standing wood (such as a market for reduced carbon emissions)
- the **wood product manufacturing subsector** decreased from $76.3 million in 2005-06 to $55.1 million in 2019-20, a decline of 47% when adjusted for inflation to 2019-20 values. In this subsector R&D aims to identify new forest-based products and methods for processed forest products (excluding pulp, paper and cardboard), such as new applications for timber in construction, new timber treatments, and the identification of new export markets
- the **pulp, paper and converted paper product manufacturing subsector** decreased from $72.2 million in 2005-06 to $50.6 million in 2017-18 (the latest year of complete data), a decline of 47% when adjusted for inflation to 2019-20 values. In this subsector R&D can cover energy efficiency in the pulping and drying of wood, and the development of new wood-based products.

For the reporting period, there was no separate industry subdivision classification that covers research on biofuels and bioenergy under the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006.

Government research and development

Data on the number of full-time-equivalent (FTE) state and territory government personnel engaged in forest-related research are presented here as an indication of levels of investment in research and development (R&D) (Table 6.2b-2). This is because data on government expenditure on forest-related R&D are not available. The FTE values are approximate and with low confidence for trends over time due to the difficulty of confirming the direct relevance of some research specifically to forests.

State and territory government research staff numbers increased from 2015-16 to 2020-21, with increases reported for the Australian Capital Territory, New South Wales and Queensland. There was a decline in research staff numbers for Tasmania. Non-government research staff were also funded by state governments in New South Wales, Queensland, South Australia, Tasmania and Victoria, however, data on the number of staff were not available.

Table 6.2b-2: Full-time-equivalent state and territory government personnel engaged in forest-related research

	State and territory government forest-related research staff (FTE)								
	2010-11			**2015-16**			**2020-21**		
Jurisdiction	**Plantation**	**Native Forest**	**Total**	**Plantation**	**Native Forest**	**Total**	**Plantation**	**Native Forest**	**Total**
ACT	0.0	7.0	7.0	0.0	7.0	7.0	0.0	15.3	15.3
NSW	12.5	12.5	25.0	8.0	8.0	16.0	17.0	22.0	39.0
NT	3.2	0.0	3.2	0.9	0.2	1.1	0.2	3.3	3.5
Qld.	31.6	1.9	33.5	20.5	1.2	21.7	11.5	13.5	25.0
SA	15.8	0.8	16.6	1.0	0.0	1.0	0.0	0.0	0.0
Tas.	52.5	62.8	115.3	2.1	5.3	7.3	1.4	3.1	4.5
Vic.	0.0	21.9	21.9	0.0	17.8	17.8	0.0	16.6	16.6
WA	1.0	22.0	23.0	0.0	15.6	15.6	2.0	13.0	15.0
Australia	**116.6**	**128.9**	**245.5**	**32.5**	**55.1**	**87.5**	**32.1**	**86.8**	**118.9**

Source: state and territory government agencies.
Click here for a Microsoft Excel workbook of the data for Table 6.2b-2.

Increases in government research staff numbers could represent real increases in capacity or could result from restructuring of government agencies and inclusion of personnel not previously identified. The decline in Tasmania after 2010-11 likely resulted from downsizing of research arms of state agencies and government business enterprises.

Governments invest in research and development relating to forest management and forest-based industries through programs conducted by Commonwealth, state and territory agencies and departments, in collaboration with research providers such as universities and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and by matching industry funding through Research and Development Corporations, specifically Forest and Wood Products Australia. Descriptions of these various agencies and their general capacity and activities are contained in Indicator 7.1e.

Adoption of new technologies

Investment in, and adoption of, new technologies have taken place across a broad range of areas of activity during the period 2016 to 2024. Notable areas include extensive use of ground-based and airborne LiDAR (Light Detection and Ranging) and other remote sensing technologies, in situ measurement of wood properties in standing trees, and increased application of genomic technology in tree breeding.

Ground-based and airborne LiDAR are now being used extensively to monitor forest structure, condition and health in most Australian jurisdictions, supporting or replacing more costly and time-consuming methods of forest inventory. Artificial intelligence (AI) is increasingly being tested and applied to further improve the accuracy and efficiency of forest management technologies and practices, such as for wildlife recognition and monitoring, and fire detection.

Examples of new technologies adopted are presented in Supporting information for Indicator 6.2b.

Supporting information for Indicator 6.2b: Investment in research, development, extension and use of new and improved technologies

Industry definitions

The Australian forestry and forest products industries are defined according to the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006. The forestry industry is equivalent to Division A, Subdivision 3 - forestry and logging. The forest products industry consists of Division C, Subdivision 14 – wood product manufacturing, and Division C and Subdivision 15 – pulp, paper and paperboard manufacturing (Trewin and Pink 2006). Forestry support services are excluded, and are reported separately under agriculture, forestry and fishing support services.

Data for reporting business research and development expenditure

Data for reporting business research and development expenditure were sourced from the biennial Australian Bureau of Statistics (ABS) survey *Research and Experimental Development carried out by businesses in Australia* (ABS 2023). A change to the collection frequency from annual to biennial was made after the 2011-12 survey. The most recent data released by the ABS in 2023 for the 2021-22 financial year were incomplete or too unreliable in each subsector for reporting here. The data released in 2021 for the 2019-20 financial year were also incomplete with no data available for the pulp, paper and converted paper product manufacturing subsector for that year.

The definition of 'Research and development' (R&D) used by the ABS is that of the Organisation for Economic Co-operation and Development (OECD): 'creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge'. This definition excludes expenditure that expands production capacity using existing technologies, but includes expenditure on basic research, on applied research, and on ways of applying research in practice ('experimental development'). The ABS data also include only intramural expenditure (expenditure undertaken within the sector) on individual R&D activities of $100,000 or more; extramural R&D (undertaken entirely by another entity outside this sector) of any value is excluded.

See the Key information for Indicator 6.2b for the data reported.

Adoption of new technologies – examples

New technologies are being developed and adopted across a range of forest settings.

New South Wales

Methods have been developed to measure historical trends in forest extent in New South Wales, which initially focused on Regional Forest Agreement regions. The methods leverage data from an extensive set of existing and historical forest monitoring programs with mobile terrestrial LiDAR (Light Detection and Ranging) data collected across plots in coastal forests which provide detailed information about forest structure that can give insight into forest condition and function. This source of information could be used for further development of forest metrics, particularly through the use of artificial intelligence to automate extraction of additional forest variables. These data have now been made publicly available through the TERN data discovery portal.

Western Australia

The use of remote sensor cameras has been significantly expanded in Western Australia since 2016 for a variety of fauna management activities, including surveying threatened species and monitoring for introduced predators. Environmental DNA biodiversity survey and monitoring methods are being trialled alongside other genomic approaches to understand the genetic health and connectivity of populations of selected fauna species e.g. western ringtail possum (*Pseudocheirus occidentalis*), quokka (*Setonix brachyurus*), woylie (*Bettongia penicillata*), chuditch (*Dasyurus geoffroii*) and quenda (*Isoodon fusciventer*). Grooming traps for feral cats such as the 'Felixer' are being trialled, and global positioning system (GPS) technology is being used to track the movement of feral cats to help inform pest management.

Geophysical methods are increasingly employed to understand how below-ground soil depth relates to forest health. Novel approaches to extract three-dimensional forest structure from radar satellite data are also being tested, to enable existing capability to be extended to densely forested areas when the NISAR (NASA-ISRO SAR) satellite is launched. NISAR is a joint National Aeronautics and Space Administration (NASA) and Indian Space Research Organization (ISRO) synthetic aperture radar (SAR) satellite, planned for launch in 2025.

As an additional example, the severity of prescribed burning and bushfires is being mapped using models developed for forests in south-west Western Australia. The models relate 'satellite-derived normalised burn ratios' to field data that measure ecological impacts of planned or unplanned fire. This tool is currently being used to improve reporting of treatment areas, and assessment of burn impacts and management effectiveness, and is intended to be used to build a more detailed and accurate historic fire regime database that incorporates severity data.

Use of artificial intelligence in fire detection and monitoring

Artificial intelligence (AI) is being increasingly applied to forest management technologies and practices including significant uptake for fire detection and monitoring systems to help protect commercial plantation areas.

Fire detection and monitoring systems using AI and machine learning technology have been tested and adopted in New South Wales, Queensland, South Australia, Tasmania and Victoria. These systems use ultra-high definition 360-degree panoramic smoke detection cameras for automated early detection of fires with very high accuracy.

Other systems based on satellite imagery are being tested with AI technology to rapidly detect fires from space by differentiating smoke from clouds.

Assessment of plantation wood quality in standing trees

Plantation wood quality can vary in terms of wood stiffness and density, as well as variability within forest stands. These variables significantly affect the value of harvested timber, but have been difficult to measure efficiently and cost effectively before trees are harvested and processed. Funding by Forest and Wood Products Australia (FWPA) has supported research by the Australian company Forest Quality to develop methods to measure wood quality in standing trees, cost-effectively and with minimal effort (Downes et al 2020).

This research utilised IML-RESI, a small-diameter resistance drill (resistograph) technology that captures details of wood quality and its variability within a tree. The recorded data are uploaded to an online wood-quality assessment platform (eCambium) to estimate average density and stiffness across the forest stand. The results allow growers to assess wood quality across their estates, support decision-making regarding the impact of plantation management and harvest on the desirable wood characteristics for stiffness and volume.

The information generated is also used by tree breeders to improve genetic gains in wood stiffness and strength for future hardwood and softwood plantation stock.

Genomic technology applications for tree breeding

Genomics is the study of the structure, function, evolution, and mapping of genomes, and has the capacity to rapidly increase the rate of genetic gain from tree breeding programs. It is playing an increasingly important role in plantation tree breeding in Australia. Because decisions made now on the selection of genetic material will affect the quality of wood to be harvested at a significant time in the future, tree breeding programs need to select genetic material predicted to be resilient to future climates and biosecurity threats.

Since the early 1980s, Tree Breeding Australia (TBA) has managed Australia's tree breeding improvement programs, collecting and analysing data, and supplying genetic evaluation services, tools and systems to the forestry industry. While the genotype (the genetic make-up) of a tree is inherited from its parents, its phenotype (its observable characteristics) is influenced by the interaction of external environmental factors with its genotype.

To support grower decision-making, TBA uses the TREEPLAN analytical system for genetic evaluation. This combines tree pedigree with phenotypic data collected in-field, and generates breeding values that can be used by growers during tree selection (FWPA 2022). These breeding values demonstrate the potential economic merits of trees for different production environments and processing outcomes, and enable the ranking of trees in different regions based on their predicted performance for traits such as growth rate, tree form (including branching and stem straightness), wood properties and health attributes.

By combining this information with genomic data, the tool can now be used to generate 'single-step' genetic evaluations, a single set of objectively comparable breeding values. Recent studies conducted by TBA and industry collaborators demonstrated that inclusion of genomic data improves the accuracy of prediction, and genetic gain (genetic improvement within a breeding population) could increase by as much as 10-15%.

Data source

ABS (2023). *Research and Experimental Development, Businesses, Australia, 2021-22*, Australian Bureau of Statistics, accessed 11 December 2023. abs.gov.au/statistics/industry/technology-and-innovation/research-and-experimental-development-businesses-australia/latest-release.

References

Downes G, Drew D, Lee D (2020). Validated softwood stiffness predictions using IML-Resistograph and eCambium, a report for Forest & Wood Products Australia, Forest & Wood Products Australia, Melbourne, Victoria.

FWPA (2022). Australian tree breeding research revolutionising the industry, R&DWorks Newsletter, Forest and Wood Products Australia, Melbourne, Victoria.

Trewin D and Pink B (2006). *Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006*. Cat. no. 1292.0, Australian Bureau of Statistics, Canberra.

More information

Learn more about the Criterion 6 of Australia's State of the Forests Report.

Web agriculture.gov.au/abares/forestsaustralia/sofr/

Download a Microsoft Excel workbook of the data presented in Indicator 6.2b.

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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