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Plant genetic resources for food and agriculture: second national report - Australia

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Summary and introduction

This is Australia's second country report to the United Nation Food and Agriculture Organisation on plant genetic resources for food and agriculture—or PGRFA. It will contribute to current and future considerations of the Commission on Genetic Resources for Food and Agriculture, especially monitoring the implementation of the Global Plan of Action on the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture. This report will also contribute to future updates of the State of the World's Plant Genetic Resources reports.

Plant genetic resources (PGR), or 'germplasm', is a term referring to the genetic diversity of plants as a resource. Genetic diversity among individuals of a species resides in populations, existing either in natural ecosystems or in human-made situations—on farms or in storage systems. Genetic diversity is fundamental to life, because at a species level it enables a breeding population to survive in space and time through the ability to adapt to changing environments and selection pressures.

To make use of genetic diversity, plant breeders require access to genetic resources from the wild (natural habitats of the species in question) and/or from repositories established to store diverse genetic resources. Repositories usually take the form of seed banks, but can also be living plant collections—for example, a collection of mango-tree varieties. More recently, genetic diversity can be maintained, and may be more appropriately maintained, as tissue cultures (for example, banana tissue cultures) or as deoxyribonucleic acid (DNA) samples.

Historically, the plant genetic diversity important for food and agriculture has comprised those species directly used by humans for food, feed, fibre and timber. In recent decades, as plant breeding has become more sophisticated, more species closely related to agricultural species (such as wheat) have been used as sources of novel genetic diversity. The term 'genetic resources' has therefore come to mean more than simply just 'seeds'. The term seed bank is also meant in general terms to include germplasm.

Plant genetic diversity is critical for food and agriculture because it enables plant breeding to be used to alter crop, pasture and forest species to meet changing environments and needs. This adaptation is critical for food security through maintaining or increasing production of plant-based agricultural systems.

Continuous modification of agriculturally important plant species is required for a range of reasons, which include:

- adapting to environmental stresses (drought, heat, frost, waterlogging, salinity, climate change)
- protecting plants against continually evolving pests and diseases
- increasing yields
- improving food, feed, fibre or timber quality
- modifying plants structurally to suit farming or harvesting systems.

Assured access to genetic resources underpins Australia's ability to maintain agricultural productivity in the face of environmental and economic challenges. Farmers and plant breeders rely on access to genetic resources to improve the quality and productivity of crops and pastures. This report documents Australia's genetic plant resources held in public collections.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a legally-binding international instrument developed to ensure the sustainable use of plant genetic resources and the sharing of benefits that arise from that use. Parties (sovereign states) to this instrument have agreed to arrangements for facilitated access and benefit sharing for a group of crop and forage species listed in Annex 1 of the Treaty. Annex 1 includes most of the globally important crop and forage species. Many of these are important to Australian agriculture, and our seed banks, other plant genetic resource collections and native flora contain plants either listed, or closely related to those, in Annex 1. This report identifies Annex 1 species in Australian plant genetic resource collections, where possible.

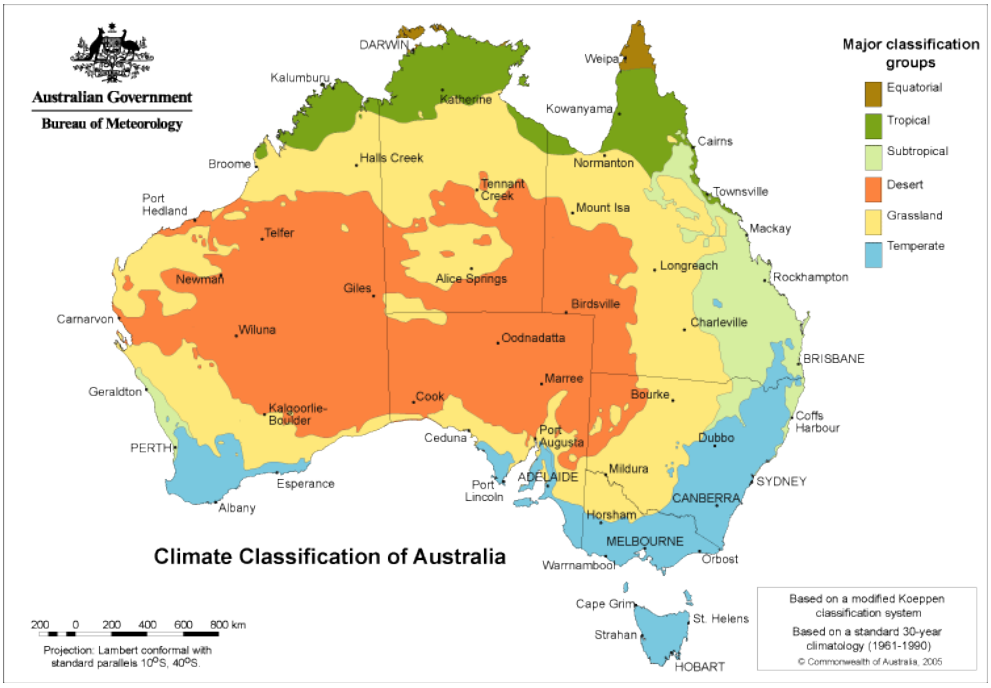
1 Australia and its agricultural sector

General information

Australia is located in the southern hemisphere and has seven external territories including the Australian Antarctic Territory. In land area Australia is the world's sixth largest nation, covering a total land area of 768 million hectares. The continent has an overall flat land surface, with relatively low precipitation and runoff rates. Mountain ranges in the south-east are often snow covered in winter, but Australia generally experiences mild winters and hot summers.

Australia's climate ranges from tropical monsoon in the north, Mediterranean in the south, to temperate in Tasmania, with a vast, arid region in the interior (Map 1). Australia's climate is highly variable, with high year-to-year rainfall variability and drought as recurring climatic features over most of the continent.

Map 1 Climate classifications in Australia



Data source: Australian Bureau of Meteorology

The population of Australia is just over 23 million people, with a density of about 2.9 people per square kilometre (ABS 2013), the lowest population density in the world. However, Australia's population is concentrated along the coastal region from Adelaide to Cairns, with a small concentration around Perth, Western Australia. Australia's population is projected to increase to between 30.9 and 42.5 million in 2056, and reach between 33.7 and 62.2 million by 2101 (ABS 2010).

Australia has a federal system of government, where powers are divided between the Australian Government (or Commonwealth) and the governments of the six states and two territories. Both levels of government are involved in policies and measures affecting the agricultural sector. With a low level of direct government support to farmers and no farm subsidy scheme, research and development (R&D) has proven to be essential in maintaining the international competitiveness of Australia's agriculture and food industries. The expenditure on R&D is seen as a partnership between government (both federal and state/territory) and industry.

The Australian Government provides funding for rural innovation primarily through research and development corporations (RDCs). RDCs are created as partnerships between government and industry to share the funding and direction setting for primary-industry R&D, investment in R&D, and the subsequent adoption of R&D outputs.

The Council of Australian Governments is an intergovernmental forum to discuss and develop nationally consistent approaches to issues. It can initiate, develop and monitor the implementation of policy reforms of national significance, particularly those that require cooperation by Australian governments, in areas such as health, education, microeconomic reform, climate change, energy, and water reform. These include issues that may arise from ministerial council deliberations. Ministerial councils play a key role in initiating, developing and monitoring policy reform, implementing nationally consistent policies and programs, and facilitating cooperation and consultation among the various Australian governments in specific policy areas.

Multilateral processes, in particular the World Trade Organization Doha Round and various bilateral or multi-party free trade agreements, are being emphasised to promote stronger trade and commercial ties between Australia and its trading partners. Free trade agreements facilitate access to new markets and can provide new opportunities, and reduce barriers in existing markets, for Australian exporters. Australia's tariff protection on imports of agriculture and food products is considered to be negligible (WTO 2011).

Over the past 40 years the Australian economy has grown and diversified considerably. There has been significant investment in export-oriented mining and energy industries, and diversification and modernisation of the agriculture sector.

Australian agriculture

Nearly 20 per cent of Australia's land mass is classified as desert. Australia has a low average annual rainfall, and rainfall across the continent is also variable. The rainfall pattern is concentric around the extensive arid core of the continent, with rainfall intensity high in the tropics and some coastal areas. Climatic zones range from tropical rainforests, deserts and cool-temperate forests to snow-covered mountains.

Within this climate, Australian plants and animals have evolved on a geographically isolated continent. Over time plants had to adapt to a slowly drying climate combined with continuing high variability. The uniqueness of much of Australia's flora and fauna is partly due to these features.

Australia's climate is dominated by the dry, sinking air of the subtropical high pressure belt which moves north and south with the seasons. This causes the rainfall pattern over Australia to be strongly seasonal and helps to define the main climate regions shown in Map 2.

In general, most crop production occurs in the blue, grey, green and yellow areas in Map 2. Fruit production and sugar growing are the major plant-based operations in the tropical regions (red) of Australia. Livestock grazing occurs in all areas except the arid centre with mixed grazing and cropping systems being limited to the southern temperate zone.

Map 2 Seasonal rainfall zones in Australia

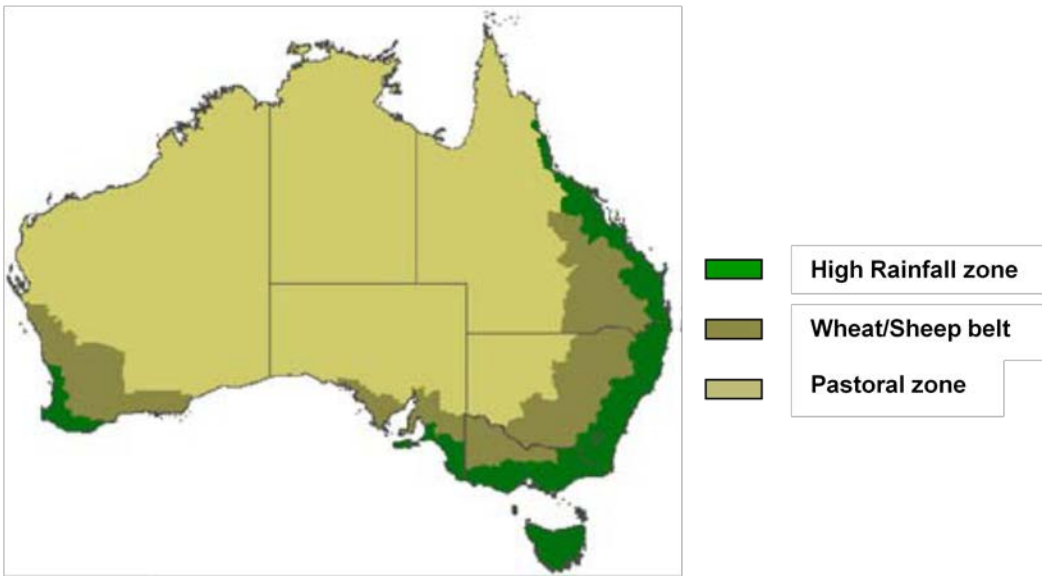
Data source: Bureau of Meteorology

Australia can be divided into agricultural production zones as shown in Map 3. The pastoral zone includes most of the northern tropical areas and the arid and semi-arid regions of Australia. Agricultural land use in this zone is characterised by extensive grazing of native pastures. Although some cropping is undertaken, inadequate rainfall makes this impractical on most farms.

The wheat–sheep zone has a climate and topography that generally allows regular cropping of grains in addition to the grazing of sheep and cattle. Grazing in this zone is generally more intensive than in the pastoral zone. Rainfall is generally adequate for producing a variety of pasture species, usually as part of a crop–grazing rotation. Farms in this zone are, on average, much smaller in area than those in the pastoral zone.

The high rainfall zone forms the greater part of the coastal belt and adjacent tablelands of the three eastern mainland states. Small areas in south-eastern South Australia and south-western Western Australia and the whole of Tasmania also fall into this zone. Higher rainfall, steeper topography, more adequate surface water and greater humidity make the high rainfall zone less suitable than the wheat–sheep zone for grains-based cropping, but more suitable for grazing and producing other crops.

Map 3 Australian agricultural zones



Note: *A*dapted from ABARE–BRS *(*2010*)*

Agriculture dominates land use in Australia, with around 52 per cent of total land area used for agriculture. The majority of agricultural land, 88 per cent, is used for grazing. Of this, 15 per cent is improved pastures and 73 per cent is other agricultural land or extensive grazing of grassland. About 8 per cent of agricultural land is used for cropping. Approximately 2 per cent of agricultural land is put aside for conservation (ABS 2010). It should be noted that some Australian farms practise both grazing and cropping in rotation.

Soil quality is a common limiting factor in Australian agriculture. Australian soils are generally shallow and highly weathered, have low fertility, and are deficient in phosphorus and/or nitrogen. As a result, nitrogen and phosphate fertilisers are extensively used. Significant parts of the continent also have salt occurring in association with groundwater, or trapped in rocks of marine origin, meaning that saline soils are a relatively common constraint to primary production.

Areas used for crop and pasture production in Australia tend to have five to nine months of effective rainfall (where precipitation exceeds evaporation) per year. Areas receiving more than nine months of effective rainfall generally grow higher value crops or tropical crops and fruits. In areas receiving effective rainfall of less than five months, cropping is usually restricted to areas that are irrigated. The northern tropical regions are suited to grazing (mainly cattle), intensive horticulture and sugarcane. In the more temperate regions, grain cropping and livestock production with low-density grazing is found. In the south, the Murray–Darling Basin (geographical area including the Darling and Murray rivers systems) supports intensive agriculture such as vegetable, fruit and dairy production.

Agriculture, fisheries and forestry make an important contribution to Australia's economic prosperity. In 2011–12, the gross value of agricultural production was $52.1 billion with crops constituting $27 billion. Australia is one of the world's largest agricultural export nations in terms of wheat, beef, dairy products, wine and wool. Agriculture and forestry occupy around 63 per cent of Australia's landmass. In 2010–11, 24 million hectares were planted to crops and Australia had 74 million sheep and 29 million cattle. In the same year the agriculture sector employed around 351 000 people (DAFF 2012).

Farming enterprises in Australia are commercial enterprises, with around 70 per cent larger than 100 hectares. However, the average farm size increased from 2720 hectares to 3340 hectares between 1983 and 2003, and in 2003 larger farms were on the whole more profitable (Productivity Commission 2005). The average age of Australian farmers is 53 years and there are fewer young famers coming through to replace them.

Key features of recent changes in Australian agriculture include:

- contraction of agriculture away from marginal areas and consolidation of farm size and enterprises
- incorporation of a mix of commodities on farm, seeking opportunities for more diverse and market-responsive production
- improvements in farming systems, integrating considerations of climate variability, soil type, soil fertility and water-use efficiency
- development of higher input–higher output systems, maximising gains from fertilisers, cultivation techniques, feedlots and irrigation
- targeted and more integrated research, development and extension, delivering improved varieties, cultivation and breeding techniques within farming systems
- rationalisation of processing and marketing arrangements, moving away from localised cooperatives to positioning commodities globally.

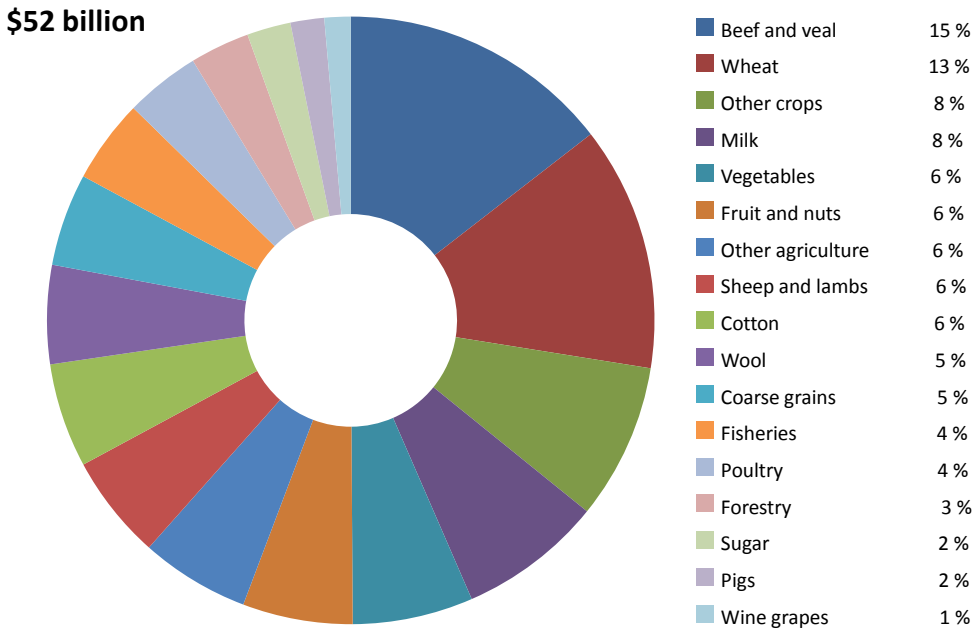
The greatest impact on agricultural production over the last ten years has been severe and extended periods of below-average rainfall in many temperate cropping and grazing areas. Given limitations to the land, labour, water and other resources available to agriculture, long-term growth in food production largely depends on increases in productivity (increases in output in excess of additional input use).

Productivity growth in Australian agriculture has been strong relative to other sectors of the economy and comparable to other OECD countries. Broadacre and dairy industries, accounting for 65 per cent of agricultural gross value of production, have achieved long-term annual productivity growth of 1.4 per cent and 0.8 per cent, respectively, for the period 1977–78 to 2007–08 (Nossal & Sheng 2010).

The gross value of Australian farm production in 2011–12 was close to $52 billion (Figure 1). This value is unchanged from 2010–11 and 20 per cent higher than 2008–09. The long and widespread droughts of 2002–03, 2006–07 and 2008–09 and lower than average rainfall in the intervening years have had a significant impact on agricultural productivity.

Australian agriculture is strongly export-oriented, with approximately 75 per cent of agricultural production by value exported annually. In 2011–12, the value of agricultural exports was $40 billion (ABARES 2013). Major agricultural exports include grains, wool, beef, sugar, dairy products and cotton (Figure 1). Over the past 20 years, exports of beef, wine and dairy products have increased significantly in response to growing overseas demand.

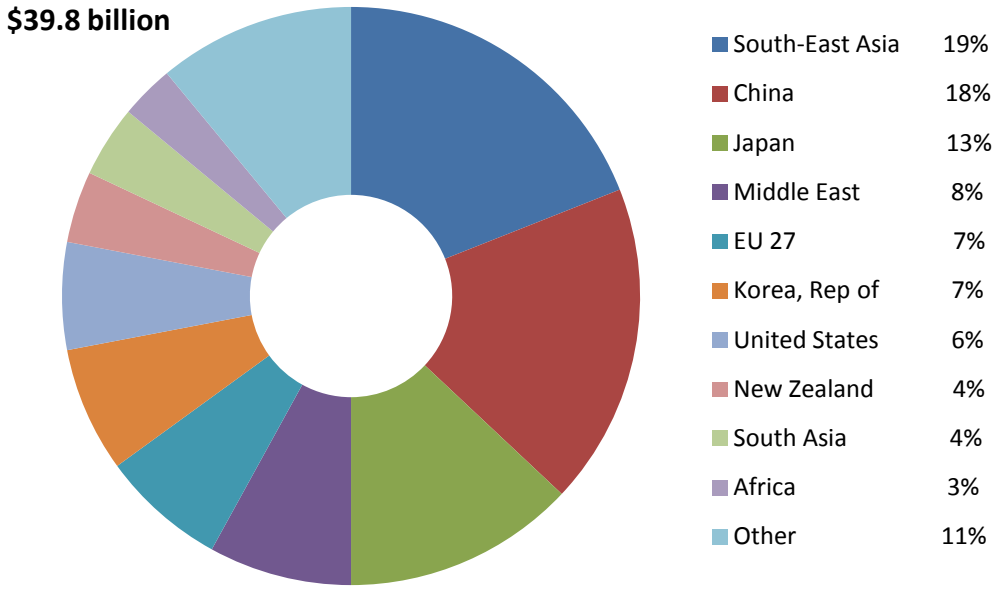
Figure 1 Gross value of agriculture, fisheries and forestry production, 2011–12



Data source: ABARES 2013

Since the 1990s, the focus of Australian agricultural exports has shifted from European to Asian markets. Figure 2 shows Australia's major agricultural export markets in 2011–12; these were South-East Asia (19 per cent), China (18 per cent), Japan (13 per cent), the Middle East (8 per cent), the European Union (7 per cent), Korea (7 per cent) and the United States (6 per cent). As Australia has a comparatively small population, most future growth in its agriculture will depend on exports.

Figure 2 Destination and value of Australian agricultural exports, 2011–12



Data source: ABARES 2013

There has been increasing recognition of the need for agriculture to become more environmentally sustainable while remaining or improving its economic viability. The decline in productive capacity of some agricultural soils due to soil-structure breakdown, acidification, salinisation and erosion is an example of the environmental sustainability issues facing Australian agriculture.

In the late 1980s the Australian Government established the National Landcare Program to encourage farmers, resource managers and other land users to take more responsibility for, and become skilled in, sustainable resource management. The program administered grants to help protect Australia's natural environment and, at the same time, sustainably produce food and fibre. At the time about 40 per cent of Australian farmers were involved in Landcare and around 4500 Landcare groups were established.

Land and resource-use decisions are also being influenced by natural-resource assessments. For example, water-resources management and environmental-flow considerations are being pursued through the water pricing reforms of the Council of Australian Governments.

Research and development arrangements for the agricultural sector

Australia has 15 research and development corporations covering virtually all agricultural industries. The RDCs bring industry and researchers together to establish strategic directions and fund projects that provide industry with the innovation and productivity tools to compete in global markets.

The 15 RDCs are a unique partnership between the Australian Government and the agriculture, forestry and fisheries industries. Their focus is on expanding Australia's rural R&D effort, improving industry effectiveness and efficiency by investing in high-priority areas, and encouraging uptake of research results to improve international competitiveness and sustainability. The RDCs commission and manage targeted research and foster the uptake and adoption of research outcomes based on the identified needs and priorities of both industry and the Australian Government. The Australian Government provides dollar-for-dollar matching of industry expenditure on R&D up to a limit of 0.5 per cent of each industry's gross value of production.

The RDC model today is a mix of statutory and industry-owned companies. The industry-owned R&D companies are independent corporate entities with expertise-based boards. The independent R&D companies were formed in response to an industry's desire to have more flexibility and control over its own affairs, increased industry representation and to foster market-driven R&D for adoption by the industry.

The RDCs most involved in plant-based production are the:

- Grains Research and Development Corporation (GRDC)
- Horticulture Australia Limited
- Rural Industries Research and Development Corporation.

Other RDCs that support the livestock industries are also relevant to plant genetic resources because their industries rely on pasture and fodder species to feed their livestock. Relevant RDCs in this context are the:

- Dairy Australia
- Meat and Livestock Australia
- Australian Wool Innovation.

2 The state of diversity

Diversity of production

Almost all plant-based agricultural commodities in Australia come from exotic species. A notable exception is the macadamia nut (*Macadamia integrifolia* and *M. tetraphylla*). The use of exotic plants in Australian agriculture started in the late 1780s when Europeans first settled in Australia. Endemic Australian plants are used in niche food industries (bush foods) and native grasses are sometimes planted as pastures or grazed in extensive livestock operations as part of the natural flora. However, it is the exotic plant species that provide the majority of food consumed domestically and exported.

Australia has no immediate food security concerns and produces more food than it consumes. While Australia exports excess grain, sugar and oilseeds, it produces almost all of its fresh fruit and vegetables. Production estimates for field crops (Table 1), fruit (Table 2) and vegetables (Table 3) are given in the Appendix. The tables also indicate which of the crops, fruits or vegetables are listed in Annex 1 to the International Treaty on Plant Genetic Resources for Food and Agriculture, and therefore covered under its Multilateral System.

Annual agricultural production in Australia varies between years for two main reasons:

- inter-seasonal variation in climate and rainfall leading to variable inter-seasonal yields
- changes in planting choices by farmers in response to changes in the international price of major commodity types.

Australia has a healthy diversity of plant-derived foods and diversity is likely to increase. The Australian population is formed from many cultural groups that have arrived in the country sequentially, building on an initial migration mainly coming from the British Isles. The integration of different cuisines has introduced new vegetable and fruit varieties that have contributed to the diversity of current agricultural production. Diversity is likely to go on increasing with the integration of new cultures and cuisines into Australian society.

In addition to introduced diversity, a greater interest in food and cooking is seeing increasing use of what are termed 'bush foods' in Australia. Bush foods are foods derived from native plants and animals. A list of the well-known bush food plants is given in Table 5 (Appendix); they include only a few species that fall under the ITPGRFA's Annex 1. Some small industries based on the agricultural production of some bush foods have developed.

Some exotic plants have escaped cultivation to become weeds in the Australian environment. Plants such as olives, blackberry and guava grow wild in Australia and are used by people and animals as a food source.

Australian agriculture produced 6.5 million tonnes of hay and silage in 2010–11. Details on the species underpinning this hay and silage production are not collected; however, it is known that about one-third of production comes from cereals, including cereals such as maize that are grown for this purpose. It will also include the cutting of poor cereal crops that, because of drought conditions, were unlikely to yield much usable grain. Cutting of poor cereal crops during initial grain filling and before senescence is seen as a better financial

outcome than trying to harvest a low yielding crop. Poor canola crops are also used as bailed fodder in this way. Cereal straw is also bailed and sold for livestock production.

Pasture species are widely used for grazing and are also cut for hay and silage. A list of pasture and fodder species recommended for use in various Australian environments are listed in Table 6 (Appendix), with species falling under Annex 1 of the ITPGRFA identified.

Diversity available to farmers

Australia has a modern, commercially-focused agriculture sector. Commercial breeding enterprises, supported by research funded by industry RDCs, provide a diversity of varieties for industry to use. In the grains sector, the National Varieties Trials (NVT) test all commercial varieties and advanced breeding lines in a range of production environments across Australia. The results of the commercial varieties trials are available to farmers online (NVT 2013) so they can choose the best varieties for their needs. Table 4 (Appendix) shows the numbers of commercial varieties and varieties under development for a range of field crops that were trialled in the 2012 NVT.

Online systems are also available for choosing pasture species to suit farming regions. Pastures Australia's Pasture Picker is an online system developed collaboratively by five RDCs (Pastures Australia 2013). In addition to online systems supported by the RDCs, many commercial pasture-seed merchants have websites that give advice on the best varieties and species for particular farming environments and requirements.

In the horticulture sector, industry associations, generally organised along commodity types, provide information to growers on a range of topics including available varieties. While these groups provide information on varieties, the supply of varieties is undertaken by commercial companies.

There are many commercial seed suppliers and nurseries that supply the cropping, pastures, fruit and vegetable farmers with their seeds and trees. Lists of companies that support these farmers are compiled by the Australian Seed Federation (ASF 2013) and Nursery & Garden Industry Australia (NGIA 2013).

Plant genetic resources supporting variety development

The majority of Australian plant-based agriculture uses exotic species meaning that it is almost exclusively reliant on exotic plant genetic resources. Consequently, the drivers for the conservation of exotic germplasm in Australia are predominantly economic. The conservation of these PGRFA will be described in more detail in Chapter 4 (The state of *ex situ* management).

In the case of the native *Macadamia* species, drivers of conservation are both economic and environmental. Research orchards of *Macadamia integrifolia*, *M. tetraphylla* and other non-food *Macadamia* species have been established to breed better varieties. Recent research has developed new varieties with double the yield of older, traditionally grown varieties.

Environmental conservation of *Macadamia* species is governed by Commonwealth and state environmental protection legislation. The governance systems related to conservation of macadamia and other native PGRFA will be discussed in Chapter 3 (The state of *in situ* management).

Australia has a contemporary, commerce-driven agricultural sector that uses modern breeding technologies to improve the yield and quality from its grains, pasture and horticultural industries. Australian agriculture produces a wide range of plant products and maintains genetic diversity by *ex situ* conservation of important species and *in situ* conservation of endemic species. These actions, together with an effective biosecurity system, allow the industries to meet market requirements relating to demand for new foods and new quality requirements, and to maintain genetic diversity of cultivated exotic species through importation of genetic resources.

3 The state of *in situ* management

In situ management of plant genetic resources entails protecting vital populations and their native environment under native conditions and native selection pressure (Hammer et al. 2003).

Australia has a high degree of biological diversity that it is committed to protecting and conserving. Australia has established a framework for the conservation of its biodiversity and is improving biodiversity conservation through the implementation of Australia's Biodiversity Conservation Strategy 2010–2030 (Natural Resource Management Ministerial Council 2010).

There are currently complementary systems in place for *in situ* conservation of biodiversity. Under agreements across the state, territory and Australian governments, the conservation of biodiversity with national or international significance falls under the purview of the Australian Government through the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). Under this Act, once a species has been listed as threatened, recovery plans can be developed and implemented to stop the decline and support the recovery of the species concerned. Biodiversity with local or regional significance can be protected under state environmental legislation. Australian governments are working towards reciprocal recognition of declarations of threatened species under various federal, state and territory biodiversity-conservation legislation.

To assist in decision making on biodiversity, information systems are being used to bring together and present data sets in a centralised and accessible format. The Australian Government has funded the establishment of the online Atlas of Living Australia to provide ready and efficient access to integrated data held in existing biological collections across the country (ALA 2013). Integrating taxonomic information, collection data, ecological and genetic information with geospatial analysis tools will help in the conservation of biodiversity. Another online tool is the Australian Virtual Herbarium which links all major Australian herbarium records into one database.

In situ conservation of native PGRFA

Four species of *Macadamia* are considered threatened under the EPBC Act with *M. jansenii* listed as endangered and *M. integrifolia*, *M. ternifolia*, and *M. tetraphylla* listed as threatened. These species are also listed under relevant state legislation in Queensland and New South Wales. A national recovery plan (Costello et al. 2009) was adopted under the EPBC Act to stop the decline and support the recovery of these four species. Their distribution can be found on the Atlas of Living Australia and details regarding herbarium specimens can be found on the Australian Virtual Herbarium.

There are other native species in Australia that are closely related to important agricultural species including those in Annex 1 of the ITPGRFA. These include species of the *Atriplex, Cajanus*, *Citrus, Dioscorea, Glycine, Gossypium, Ipomoea, Musa, Oryza, Solanum, Sorghum* and *Vigna* genera. Native Australian species of the *Cajanus, Citrus, Dioscorea, Ipomoea, Musa, Oryza, Solanum*, *Sorghum* and *Vigna* genera are relevant to Annex 1 of the ITPGRFA and are listed in Tables 7 to 16 (Appendix) respectively. Three *Solanum* species (*S. carduiforme, S. dunalianum, S. karsense*) are listed as threatened under the EPBC Act, as is *Atriplex infrequens*.

One species of *Ipomoea* (*I. polpha subsp. latzii*), known as the giant sweet potato, is considered rare and used as a food source by Indigenous Australians. Crase and colleagues (2010) have mapped its distribution and conclude it would be considered vulnerable under Criteria 1 of the International Union for Conservation of Nature.

Australia has four (Henry et al. 2010) or five (Australian Plant Census 2013) native species of *Oryza* (rice) depending on the source of information. Most of these species are abundant across their range. One species, *Oryza officinalis*, has, however, been recorded in only two very remote locations in northern Australia; more study could be undertaken to determine its distribution and population size. Henry and colleagues (2010) state that there are no Australian native accessions of this species in the Australian Tropical Crops and Forages Germplasm Centre or in the International Rice Research Institute of the Consultative Group on International Agricultural Research (CGIAR) in the Philippines.

The *Glycine* genus which includes soybeans, but is not covered under Annex 1 of the ITPRGFA, has 25 species that are endemic to Australia. One on these, *G. latrobeana*, is listed as a threatened species under the EPBC Act and recovery plans are in place for this species.

Gossypium, the cotton genus, and *Sorghum* are also well represented in Australia with many endemic species, but none are listed as threatened by Australian governments.

The majority of native Australian species relevant to food and agriculture are not threatened and are not the subject of specialised conservation efforts. Should *in situ* conservation be required, both state and national legislation allows for the declaration of threatened (or similar) species status, which gives legislative authority to conservation measures.

In addition, all Australian flora are subject to scientific research through a network of Australian herbariums and through the Australian Centre for Biodiversity Research. Taxonomic studies of all Australia flora, including the genera listed above, ensure that PGRFA are inventoried and documented. However, the focus of taxonomic research is on Australian plant biodiversity in general, not specifically Australian PGRFA. Australia also has an extensive network of national parks and state reserves that provide natural habitat for the preservation of native flora.

Scientific research on Australian PGRFA, both in Australia and internationally, uses modern techniques to determine the relationships between agriculturally important crops and their relatives in the Australian flora. Examples of this are *Ipomoea* (Miller et al. 1999), *Sorghum* (Price et al. 2005) and rice (Henry et al. 2010; Nonomura et al. 2010). While there are some examples specific to crops, it should be noted that Australian flora have been collected by international expeditions for many reasons, including their potential value for food and agriculture, and are conserved in *ex situ* collections overseas. Examples of this are found in Miller et al. (1999) where Australian native *Ipomomea* species were sourced from collections in the United States of America and commercial seed suppliers in Europe.

The future *in situ* management of Australian flora is covered by Australia's Biodiversity Conservation Strategy 2010–2030 which includes outcomes that will:

- increase the accessibility of science and knowledge for biodiversity conservation
- improve the alignment of research with biodiversity-conservation priorities

- increase the application of knowledge of biodiversity conservation by all sectors and communities.

While the strategy will see improvements in biodiversity conservation in Australia, conservation of native Australian PGRFA may benefit from focused efforts to determine and document information relevant to its *in situ* conservation.

Aside from government conservation approaches, commercialisation of Australian native food plants may provide impetus for *in situ* conservation efforts from the private sector. Australia is promoting the use of native PGRFA through the research of the Rural Industries Research and Development Corporation, and its support of the New Rural Industries Association. Industry associations such as the Australian Native Food Industry Limited also advance the development of markets for, and recognition of, Australian native foods.

4 The state of *ex situ* management

Ex situ conservation of plant genetic resources involves the conservation of PGRFA outside their natural habitat (ITPGRFA, Article 2), generally through the maintenance of collections of seeds or whole plants (e.g. orchards, tissue-culture collections). The aim is to conserve genetic variation within species. The commercial growth of plants for production of food, forage or fibre is not generally considered to be an *ex situ* conservation activity.

Almost all of Australia's plant-based agriculture relies on the *ex situ* conservation of exotic plant genetic resources. Most agricultural species are exotic to Australia and the development of past and current varieties has relied on the import of plant genetic resources. The CGIAR seed banks have played a major role in the provision of plant genetic resources along with access to *in situ* specimens in their country of origin. These growing collections of material have been stored by state government agriculture agencies and research organisations.

Plant genetic resources centres

The history of organised and coordinated *ex situ* seed bank collections in Australia began in the mid-1970s with the formation of a network of plant genetic resource centres (PGRCs). Since then, the federal and state governments, along with some RDCs, have had policy responsibility for the management and strategic direction of the PGRCs.

At the start of 2013 there were five PGRCs in the network:

- Australian Winter Cereals Collection, Tamworth, New South Wales
- Australian Temperate Field Crops Collection, Horsham, Victoria
- Australian Tropical Crops and Forages Collection, Biloela, Queensland
- Australian Medicago Genetic Resource Centre, Adelaide, South Australia
- Australian Trifolium Genetic Resource Centre, Perth, Western Australia.

The status of these PGRCs is changing in 2013 and beyond. Although not officially opened, a new cereals seed bank is being created in Horsham at the current site of the Australian Temperate Field Crops Collection. The new centre will be known as the Australian Grains Genebank and will consolidate tropical and temperate-climate cereal, grain-legume and oil-seed collections currently held in the Australian Temperate Field Crops Collection, the Australian Winter Cereals Collection and the Australian Tropical Crops and Forages Collection.

Arrangements are nearing finalisation for another new seed bank to consolidate the forage and forage–legume collections currently held at the Australian Tropical Crops and Forages Collection, the Australian Medicago Genetic Resource Centre, the Australian Trifolium Genetic Resource Centre, and forage repositories in Tasmania, Victoria and New South Wales. This new centre is likely to be known as the Australian Pastures Genebank and will be located in Adelaide at the current site of the Australian Medicago Genetic Resource Centre.

When these changes are complete, the collections of the five PGRCs will be consolidated into one grains collection and one forages collection.

In addition, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed the Indigenous Relatives of Crops Collection. This collection contains some 2000 accessions of the Australian *Glycine* species and 400 accessions of 17 *Gossypium* species, but has not been used in research programs for several years. When used for research, this collection did not function as a seed bank for breeding new varieties. Most of the research on wild *Glycine* was on geographic distribution, interspecific hybridisation, cytogenetics, photoperiod responses, population genetics and breeding systems. The research on Australia's 17 native *Gossypium* species was focused on phylogenetics, interspecific hybridisation, evolutionary relationships and two traits relevant to cotton cropping: natural insect pest resistance and resistance to the fungal pathogen *Fusarium.* The collection, housed at the CSIRO laboratories at Black Mountain, Canberra, now functions more as a herbarium than an active seed bank.

The facilities at CSIRO where this collection is housed are also used to store the backup collections of the five PGRCs described in detail below. Some of the temperate pastures and forages in the major seed banks are also backed up at Margot Forde Forage Germplasm Collection in Palmerston North, New Zealand.

Details of the collections held in the five PGRCs and three other grain/forage collections (described below) are given in Tables 16 and 17 of the Appendix. Table 16 gives information about the material in each collection that falls under Annex 1 of the ITPGRFA. Table 17 gives information about material in the collections not covered by Annex 1.

Australian Winter Cereals Collection

The Australian Winter Cereals Collection, located in Tamworth, New South Wales, is a grain-crops collection, holding primarily wheat (*Triticum, Secale, Triticosecale, Aegilops, Agropyron* and their hybrids), barley (*Hordeum*) and oats (*Avena*) germplasm. These genera are the most valuable grain crops in Australia, in terms of both gross value of production and export commodities value. This seed bank includes a mix of varieties, cultivars, breeding lines, weedy relatives and traditional cultivars/land races, as well as research, mutant and non-cultivated accessions from all over the world. About 25 per cent of the land races held are unique to the collection.

Auricht and colleagues (2009) updated information on accessions, characterisation and distribution for the five major seed bank collections in Australia. They recorded total accessions in this collection at 54 317; in 2012, total accessions were 63 239.

Australian Temperate Field Crops Collection

The Australian Temperate Field Crops Collection, located in Horsham, Victoria, primarily houses temperate pulse and oil-seed crops, including pea *(Pisum),* chickpea *(Cicer),* rapeseed *(Brassica),* vetch *(Lathyrus),* lentil *(Lens),* linseed *(Linum),* bean *(Vicia),* safflower *(Carthamus),* and miscellaneous crops accessions. Auricht and colleagues (2009) recorded the collection's total holdings at 34 011 accessions. In 2012, this seed bank's accessions totalled 29 341 following auditing of the collection to remove accessions with no stored seed.

The Horsham seed bank has incomplete coverage of the wild relatives of its mandated crops; the current wild-relatives collection comprises 450 wild relatives of pea, lentil and chickpea, some of which are reselections of original accessions, and also approximately 1000 relatives of *Brassica* crops. Although the number of wild *Brassica*-related genera is large, not all related genera are represented in the Horsham seed bank.

A number of the accessions held at the Horsham seed bank are unique: many land races or wild relatives are no longer available in cultivation or in traditional habitats, and exist only in *ex situ* collections. Recent collection trips in China found that farmers were in transition, switching from traditional land races to modern pea and faba bean varieties.

Australian Tropical Crops and Forages Collection

The Australian Tropical Crops and Forages Collection, located in Biloela, Queensland, is a significant collection in several ways. First, it is the primary Australian collection of tropical PGRFA; second, it is a very diverse collection in terms of genera and species; and third, it includes a strategic collection of indigenous relatives of crop species. Auricht and colleagues (2009) recorded the collection's total holdings as 39 653 accessions; in 2012 total holdings were 40 667 accessions.

As well as holding tropical crops germplasm, this collection also has an extensive range of tropical forage grasses and legumes (both annual and perennial species), diverse fibre-crop holdings, and a collection of horticultural, herb and spice germplasm. Tropical field crops include adzuki, amaranth, coriander, cotton, cowpea, culinary bean, guar, kenaf, maize, millets, mung bean, navy bean, peanut, pigeon pea, sesame, rice, sesbania, sorghum, soybean, sunflower, tobacco, tomato and winged bean.

Tropical forage species of grasses, legumes and shrubs include *Aeschynomene*, *Cenchrus, Centrosema, Desmanthus, Digitaria, Leucaena, Macroptilium,* native *Panicum, Stylosanthes* and *Urochloa.* The 11 000 accessions of tropical forages collected from Africa, the Americas and Asia are significant because half are not held by any other seed bank in the world.

The centre has taken a lead in assembling, cataloguing and regenerating the indigenous wild-relative collections of millets (such as *Sorghum, Pennisetum* and *Cleistachne*), mung bean and cowpea (*Vigna*), pigeon pea (*Cajanus*), tobacco (*Nicotiana*), rice (*Oryza*) and cotton (*Gossypium*). These indigenous wild-crop relatives constitute a significant Australian contribution to global PGRFA.

Australian Medicago Genetic Resource Centre

The Australian Medicago Genetic Resource Centre, located in Adelaide, South Australia, holds accessions of annual and perennial temperate pasture legumes, including *Astragalus, Hedysarum, Lotus, Medicago, Melilotus, Onobrychis* and *Trigonella*. Auricht and colleagues (2009) recorded the centre's total holdings as 41 490 accessions; in 2012 accessions totalled 45 718.

The centre maintains the world's largest collection of *Medicago* and temperate pasture legume species and has a substantial collection of salt-tolerant and native fodder species. It is an invaluable collection, particularly of *Medicago* species, because 95 per cent of the accessions are not represented in any other collections in the world.

Pasture legume accessions were collected predominately from alkaline and saline soils in the Mediterranean and surrounding regions by Australian scientists over the last 50 years and are unique to the Australian Medicago Genetic Resource Centre. There is also a smaller collection (2000 accessions) of temperate forage grasses, and salt-tolerant herbs and shrubs.

Australian Trifolium Genetic Resource Centre

In 2007 the Australian Trifolium Genetic Resource Centre, located in Perth, Western Australia, held 17 500 accessions of *Trifolium, Ornithopus, Biserrula, Dorycnium* and other temperate pasture legumes adapted to acid soils. Auricht and colleagues (2009) recorded the centre's total holdings as 17 506 accessions. No new accessions have been added since 2009.

This collection of pasture legumes, collected mostly from the Mediterranean, is significant because most species are poorly represented in *ex situ* collections in the countries of origin. The collections of annual *Trifolium* and *Ornithopus compressus* are of particular significance. The *Trifolium* collection is used extensively in the National Annual Pasture Legume Improvement Program.

The other major collection of *Trifolium* in the world is held at International Center for Agricultural Research in the Dry Areas (ICARDA), whose germplasm is mostly from Syria, Jordan and Tunisia, with some from Morocco and Algeria. The collection at ICARDA and the much larger collection at the Australian Trifolium Genetic Resource Centre together form the most important *ex situ* germplasm collection of Mediterranean *Trifolium* in the world. The collection of yellow serradella held in Perth is also the most comprehensive and important collection in the world.

Trifolium, Ornithopus, Biserrula and other species generally adapted to acid soils have application to many parts of southern Australia. Many new cultivars *of Trifolium, Ornithopus* and *Biserrula* have been developed by Western Australian plant breeders and researchers since the collection was established in 1984. Cultivar development has focused on adaptation to sandy, acid soils from high-rainfall permanent pasture to low-rainfall pasture–crop rotation systems.

The conservation value of most of the germplasm is high; more than 90 per cent of the germplasm is from collections made in the wild by Australian researchers and consequently unique in the world of *ex situ* seed banks. Less than 10 per cent of the germplasm has been sourced from other *ex situ* seed banks. Most of the germplasm is of high-priority species, since Australian researchers were focusing on a limited range of priority species.

Other *ex situ* collections

Government and universities

Other significant Australian collections of crop and forage plant genetic resources under the control of state governments and universities include:

- a temperate pasture grass and legumes collection at the Victorian Department of Primary Industries, Hamilton, Victoria (10 453 accessions)
- a cool temperate forage collection at Mt Pleasant Plant Materials Centre, Launceston, Tasmania (4500 accessions)
- a collection of barley (developed by the University of Western Australia, Perth) which was transferred to the Australian Grains Genebank in late 2012 .

All of these collections have part or all of their holdings duplicated in the major PGRCs but some of them hold material that is unique in Australian collections, and perhaps globally. The content of these collections is also outlined in Table 16 of the Appendix.

A further set of smaller collections, mostly fruit and nut genetic resources, are maintained in sites around Australia by federal, state and territory government agricultural research agencies. These collections are described in Table 18 of the Appendix.

Non-government organisations

While private-sector collections are not covered in this report, some non-government organisations (NGOs) are active in the conservation and distribution of plant genetic resources in Australia. For example, the Rare Fruit Society of South Australia promotes the maintenance and propagation of rare and heritage-variety fruit trees. Twenty-one genera of fruit plants are represented with 643 different varieties including 185 varieties of apples. Apples are listed in Annex 1 of the ITPGRFA.

Heritage vegetables and fruit are also conserved and distributed by groups such as the Seed Savers Network and the Diggers Club. The Diggers Club maintains stocks of older varieties of fruit and vegetables and sells these to club members to fund conservation and collection of more material from a variety of sources. More than 400 different vegetable and fruit varieties are available through the club. The major groups covered are asparagus, brassica vegetables, tomato, eggplant, pea, bean, herbs and fruit such as apple, pear, citrus, strawberry and the berry family. Some of these groups fall under Annex 1 of the ITPGRFA. The Seed Savers Network has decentralised the conservation of rare seeds and varieties to small local seed saving groups.

The development of both these NGOs probably stemmed from concerns about the perceived industrialisation of agriculture and threats from commercial seed companies that either use genetic modification in their products or produce hybrid varieties aimed at maximising food production. Both these NGOs support organic agricultural methods.

The private sector, while not covered in this report, may have some collections of plant genetic resources. Commonwealth and state research agencies have transferred collections to industry groups at the end of breeding programs for these industries.

The state of collections

Australia's PGRCs operate to well established, internationally accepted, methodologies (e.g. Genebank Standards 1994) so far as their resources allow (Auricht et al. 2009).

Collecting

The major Australian seed banks increase their holdings through the importation of material from international seed banks or through deposit of material by Australian researchers who generated or acquired the material independently. In recent years there have been very few collection expeditions meaning that few accessions are added through this route.

Decisions on new accessions into the seed banks are dictated by the strategic research priorities of the industry. For example, the wheat industry has initiated the CIMMYT–Australia–ICARDA germplasm evaluation (CAIGE) project where selected material from CIMMYT (International Maize and Wheat Improvement Center) and ICARDA are imported and characterised under Australian conditions.

Storage facilities

Australian seed banks vary in the way they store and utilise their plant genetic resources; in general, low moisture and low temperature storage (–20˚C) is a key feature of the major seed banks. Some seed banks also maintain working collections that are stored at or around 2˚C. Australian seed banks are generally well equipped with facilities for the storage of plant genetic resources and have constant and reliable power supplies.

Documentation and characterisation

All the seed banks have electronic systems for storage of information relevant to each accession; however, these have mostly been developed 'in house' and have not yet been integrated into a functional national system covering accessions in all major seed banks. Most of these systems record passport and characterisation data, but this information is generally not broadly available on the internet. One exception is the Australian Plant Genetic Resource Information Service, an online system containing passport and characterisation data for the Australian Tropical Crops and Forages Collection at Biloela, Queensland. While the PGRCs may not all have an online presence, some passport and characterisation information about the centres' material is available in international systems such as the International Crop Information System (ICIS) developed by the CGIAR. Information about the Australian Temperate Field Crops Collection's lentil and chickpea holdings are available through ICIS. The Australian Winter Cereals Collection in Tamworth has distributed information about its holdings on compact disc to international stakeholders.

When the five PGRCs are consolidated into two new centres, it is expected that both will use the GRIN-Global system. The Genetic Resources Information Network (GRIN) is being developed as an internet-based information-management system for the world's plant genebanks. Once Australian plant genetic resource information is available in GRIN-Global, international reseachers will be able to access information from these and other global genebanks using Genesys.

Movement of germplasm

The number of movements of germplasm in (accessions added) and out (material distributed) of each of the five major PGRCs is given in Tables 19 and 20 respectively of the Appendix. The details of each of these movements are recorded in each centre's information-management systems.

Role of botanic gardens

Australian botanic gardens have little or no role in the conservation and distribution of plant genetic resources directly relevant to mainstream Australian agriculture. However, they have an important and central role in the conservation of, and research on, Australian native plants, including native bush-food plants and those related to major agricultural species.

The Australian states have a history of recognising the importance of native species conservation and management of native species, especially rare and endangered species. The following institutions are members of the Australian Seed Bank Partnership:

- National Seed Bank, Australian National Botanic Gardens, Canberra, ACT
- WA Seed Technology Centre, Botanic Gardens and Parks Authority, Perth, Western Australia

- South Australian Seed Conservation Centre, Botanic Gardens of Adelaide, Adelaide, South Australia
- Brisbane Botanic Gardens, Mount Coot-tha, Brisbane, Queensland
- Northern Territory Seed Bank, Parks and Wildlife Commission, Darwin, Northern Territory
- PlantBank, Royal Botanic Gardens and Domain Trust, Sydney, New South Wales
- Victorian Conservation Seed Bank, Royal Botanic Gardens, Melbourne, Victoria
- Tasmanian Seed Conservation Centre, Royal Tasmanian Botanical Gardens, Hobart, Tasmania
- Threatened Flora Seed Centre, Department of Parks and Wildlife, Perth, Western Australia.

All nine centres conserve rare and endangered native-plant species. The centres in Western Australia are using cryogenic tissue storage as a supplementary conservation strategy for critically endangered species.

New South Wales funded the establishment of a native-species seed bank, PlantBank, at the Australian Botanic Gardens, Mount Annan, near Sydney. This facility received a $15 million infrastructure grant in the 2010 state budget and opened in October 2013. The PlantBank is developing cryogenic storage techniques for species that are difficult to store using standard techniques.

A number of these centres received additional funding for their native germplasm conservation and management efforts through the Millennium Seed Bank Partnership based at the Royal Botanic Gardens, Kew in the United Kingdom (UK) and funded by the UK National Lottery. The Millennium Seed Bank Partnership is a global strategy for conservation of plant species. Australian partners include all states and territories apart from the Australian Capital Territory. The priority for the first phase of this project was to bank plant species considered rare or threatened in order to dramatically enhance the conservation of Australian flora. During this first phase, a third of Australia's flora and 25 per cent of threatened species were secured in native flora conservation seed banks. These collections are duplicated at the Millennium Seed Bank in the UK.

Australian partners formed a national seed bank network, Australian Seed Conservation and Research, to harmonise activities across the project partners. The network helped to ensure that teams in each region were not duplicating collections, and promoted collaboration among research groups from each state and territory. Millennium Seed Bank funding for the network finished in 2010, when the Australian Seed Bank Partnership was formed.

This partnership is a collaboration of 14 organisations bringing together expertise from the nation’s leading botanic gardens (see above), state environment agencies, academic institutions and non-government organisations (http://seedpartnership.org.au/). The partnership is the conservation program of the Council of Heads of Australian Botanic Gardens. It is supported from the Director of National Parks statutory agency, which employs a national coordinator for the program and resources the secretariat through the Australian National Botanic Gardens. The partnership’s mission is to advance a national effort to

conserve Australia's native-plant diversity through collaborative and sustainable seed collecting, banking, research and knowledge sharing.

The Australian Seed Bank Partnership, through the *Atlas of Living Australia*, has created an online seed hub with information on the conservation native-seed accessions in Australia (http://asbp.ala.org.au). The Northern Territory native-seed accessions data are currently being negotiated for inclusion in this online hub.

These cooperative arrangements assist in clarifying and ensuring access arrangements for native-species germplasm of relevance to food and agriculture. The Australian Government's access and benefit-sharing legislation, which implements obligations under the Convention on Biological Diversity and regulates access to native species in Commonwealth areas, is part of the EPBC Act. Queensland and the Northern Territory have legislated access and benefit-sharing regimes for native biodiversity, while all states continue to implement access regimes for native species under their jurisdiction. Access issues both within and between states have the potential to become more complex as native-species germplasm is increasingly sought and used for agricultural plant breeding. National implementation of the Nagoya Protocol will provide an opportunity to ensure a nationally consistent approach to this issue.

Australian herbariums play an important role in documenting Australian flora, including those relevant to food and agriculture. For example, all information presented in Tables 7 to 15 in the Appendix was derived from resources provided collectively by national and state-based botanical gardens and associated herbariums. Samples of some Australian native plants have been provided to foreign *ex situ* collections by state herbariums. Collection expeditions to Australia to gather plant genetic resources for agricultural or other uses are informed by Australian herbarium records. All the conservation seed collections made by members of the Australian Seed Bank Partnership have a linked specimen in one of Australia's herbariums.

Assessment of major *ex situ* needs

Policies for the major Australian PGRCs have been under discussion and revision by federal and state governments for many decades. In the early to mid-2000s there were several reviews that looked at the needs of these Australian *ex situ* collections in the light of international developments in access to PGRFA.

These reviews informed a collective decision by federal and state ministers for primary industries to establish a National Genetic Resources Centre (NGRC) to coordinate the operation of Australia's plant genetic resource centres. A two-node model for the NGRC was later agreed, with one node for grains and the other for pastures. As previously discussed, the future establishment of the Australian Grains Genebank in Horsham and a pastures collection in Adelaide will give effect to the two-node National Genetic Resources Centre.

The formation of the two nodes of the NGRC will address the longer term needs of Australian *ex situ* collections identified in reviews conducted in the 2000s. The formation of the NGRC is expected to:

- increase focus on the conservation, distribution, documentation and strategic acquisition of genetic resources (mainly seeds), and associated information management, for research providers

- allow more effective management of the collections through a single governing entity that will include all relevant RDCs
- offer economies of scale and operational efficiencies from the consolidation of five or more collections into two collections held at the largest and most modern facilities, including staffing efficiencies and greater training opportunities
- allow the collections to be brought under one information-management system that will allow, among other things, online access to accession information and facilitate the availability of the material in the ITPGRFA's multilateral system.

5 The state of use

The purpose of both *ex situ* and *in situ* conservation of plant genetic resources is that they may be used now and in the future. Ultimately, plant genetic resources are utilised through the cultivation of farmers' local varieties and varieties developed by professional plant breeders, the harvesting of wild-food plants, and the management of grasslands in pasture systems and the exploitation of forests (FAO 1998). This chapter focuses on the use of plant genetic resources in Australian *ex situ* collections.

Nature of utilisation in Australia

Germplasm evaluation

The evaluation of plant genetic resources provides information about the various useful traits of the conserved germplasm accessions that could facilitate their utilisation by breeders, researchers and farmers.

In Australia, germplasm evaluation is undertaken at the sites of the major PGRCs, sometimes by staff of the PGRCs, but mostly at remote sites where pre-breeding (germplasm enhancement) research is undertaken. There is a general understanding that evaluation should take place in the environment in which the crop is to be grown. Australia's diverse and dispersed agricultural environments preclude large-scale evaluation at the PGRC sites.

It is not uncommon for research stations to receive large collections of material from the PGRCs to run evaluation experiments. In some cases these stations have stored this material and added to it through international acquisitions or collection expeditions. These research-station collections have become an important repository of unique and duplicated materials together with valuable evaluation data. These materials are increasingly being deposited into the PGRCs by the research organisations to ensure long-term conservation of these unique sources of diversity.

Movements of material from the PGRCs to researchers are recorded by the PGRCs. However, any evaluation data generated by researchers is not necessarily sent back to the PGRCs and their curators do not all agree that their role is to store and manage this evaluation data. Nevertheless, Australian scientists use modern evaluation techniques and are effective in using this information to make selections for crop improvement. Formalised programs such as CAIGE are being developed to ensure that this evaluation data is captured by PGRCs to add valuable information to the collections.

The Australian Government is supporting the development of infrastructure for use in high-throughput evaluation of plant genetic resources. Through the National Collaborative Research Infrastructure Program, the government funded the formation of the Australian Plant Phenomics Facility (www.plantphenomics.org.au). This facility provides state-of-the-art capabilities for plant phenotyping, offering controlled environments, field-based plant growth monitoring using high-throughput robotics, automated imaging and computing technologies. Researchers are able to measure the attributes of plants and relate these to their genetic make-up.

Germplasm enhancement

Following evaluation of germplasm and the identification of traits of interest, researchers will introduce traits into elite breeding lines. This process is known as pre-breeding and aims to introduce traits of interest from the genetic resource into breeding material that is as near as possible to the most modern varieties. Because genetic material is transferred in large sections containing many genes, the transfer of a new gene from a wild relative or land race may also bring genes that are detrimental to modern varieties' yield or quality characteristics. For this reason, researchers funded by the RDCs do most of the pre-breeding to introduce new traits into the latest elite breeding lines.

Australia has focused on integrated research, meaning that groups using modern techniques are brought together to deliver products that cross many parts of PGR utilisation. Research collaborations are able to evaluate germplasm, introduce new traits into material appropriate for breeding, and produce new varieties.

Plant breeding and crop improvement

As discussed above, collaborative groups are tasked with improving specific crops by screening germplasm, identifying traits, bringing those traits into elite breeding lines, and—depending on the crop—creating new varieties.

The model for the wheat breeding chain has been described by the Grains Research and Development Corporation (GRDC 2011). In the wheat breeding arena there are four private breeding companies that use the outputs of industry-funded pre-breeding research. However, this was not always the case; most of the current companies were formed through the privatisation of public and industry-funded breeding programs.

Some crops with lower production volumes have varieties that were developed by public-sector agencies, at times in partnerships with private-sector investors. For example, durum wheat breeding is funded by the GRDC, the New South Wales Department of Agriculture and a major pasta manufacturing company.

In the canola industry, the National Brassica Germplasm Improvement Program is supported by the GRDC as the focus of research investment in canola pre-breeding work. This program is able to focus on difficult traits that are beyond the scope of commercial breeding programs. As new appropriate germplasm is discovered, it is offered non-exclusively to all canola breeders. Private canola breeders collectively have an influence on the research priorities of the program through an advisory group. It should be noted that governments and companies collaborate to allow the testing of breeding material at a range of locations across Australia.

In the horticulture sector, breeding of fruit, vegetables and nuts is undertaken in a similar way, but perhaps not to the extent of the grains sector. The responsible RDC, Horticulture Australia Limited, works with state government agriculture departments to both fund research and develop new varieties. There are Australian breeding programs for a range of fruit and vegetables, but in some classes Australian industry relies on internationally bred material. International varieties are tested in Australia by seed companies and offered for sale if performance is acceptable.

Seed production and distribution

Australian has a well-developed seed production and distribution industry in both the grains and horticulture sectors. Wholesalers contract seed producers and distribute varieties

through a range of companies. The major agricultural service companies that provide agricultural merchandise of many descriptions also retail seed for many companies.

Performance information on all available grain varieties in a wide range of production environments is supplied to farmers through the National Variety Trials. NVT is run by a not-for-profit company established to provide information to growers and their advisers on the performance of field-crop varieties in Australia. The company, the Australian Crop Accreditation System, is supported by the GRDC.

6 The state of national programs, training and legislation

Australia has national programs relevant to the conservation and use of plant genetic resources, advanced educational systems to provide training, and a range of legislation that supports plant genetic resource use.

National programs

In Australia the responsibility for policy oversight of PGRFA lies with the Standing Council on Primary Industries (SCoPI), one of several standing councils under the Council of Australian Governments. SCoPI membership includes all Australian (federal, state and territory) and New Zealand ministers for primary industries matters.

In 2006, SCoPI, then called the Primary Industries Ministerial Council, agreed to the establishment of the National Genetic Resource Centre to coordinate the operation of Australia's Plant Genetic Resource Centres, achieve improvements and efficiencies, and place the centres on a more secure long-term financial footing. Following this decision, the two-node model for the NGRC was developed.

In addition to these decisions and discussions, SCoPI oversees the National Primary Industries Research Development and Extension (RD&E) Framework which aims to encourage greater collaboration and promote continuous improvement in the investment of agricultural RD&E resources nationally. Under the framework, Australian, state and territory governments, rural RDCs, universities and the CSIRO have agreed to collaborate to strengthen national research capability and better address sectoral and cross-sectoral RD&E.

Each industry sector assesses its RD&E capacity, research priorities, emerging needs and opportunities, and develops an RD&E strategy for the sector. Both sectoral and cross-sectoral strategies have been developed to coordinate national research and to form the basis of a more efficient and effective national RD&E system. To date, RD&E strategies have been developed for sectors that rely on plant genetic resources housed in the Australian *ex situ* collections including the grains, horticulture, dairy, sheepmeat, beef and wool sectors. The grains industry has long appreciated the importance of plant genetic resources to its long-term profitability and this is reflected in its RD&E strategy. Those strategies that do not explicitly state a role for genetic resources centres do implicitly acknowledge the importance of improved plant primary production for their industries.

Information systems

Australia is a modern country and has embraced information technology in many areas including in those related to plant genetic resources.

The two new genebanks for crops and pastures will use GRIN-Global as their information-management system. GRIN-Global is a germplasm resource information network (GRIN) jointly developed by the US Department of Agriculture's Agricultural Research Service, Bioversity International and the Global Crop Diversity Trust. The current Australian PGRCs use other IT systems that were often developed in-house and have limited capacity for data sharing and internet access.

Training

Thirteen of Australia's 39 universities offer undergraduate degrees in agriculture or in areas related to agriculture, such as plant science. Bachelor and postgraduate degrees in agriculture are offered in these universities. In general, the training required to utilise genetic resources in plant breeding is delivered in two ways: postgraduate degrees and on-the-job training in public or private research organisations. The state departments responsible for agriculture have plant breeding operations and have also provided the infrastructure and staff for the PGRCs. This system ensures that agricultural scientists are trained for plant breeding in both public and private sectors and also allows potential seed-bank curators to be trained in genetic resource evaluation and conservation.

Private sector

In the seed-production sector, the industry's peak body, the Australian Seed Federation, has arrangements with independent companies to provide standards, certification and training services. The Australian Seeds Authority is licensed by the Australian Government Department of Agriculture to undertake the role of the National Designated Authority for the OECD seed schemes, and, at the request of the Australian seed industry, operates the Australian Seed Certification Scheme, used principally for seed not destined for export. The Australian Seeds Authority in turn licenses three certification agencies, Seed Services Australia, AsureQuality and Agwest Plant Laboratories, through formal authorisation agreements to undertake the day-to-day operations of seed certification.

Non-government organisations

Non-government organisations also have a role in training people on how to preserve seeds through participation in community seed saving networks. The seed savers network, established in Australia in 1986, is an example of an NGO with global reach that encourages people to preserve plant genetic resources in their communities.

National legislation

Australian legislation relevant to plant genetic resources is listed below.

The *Quarantine Act 1908* and the *Export Control Act 1982* provide phytosanitary controls for entry and export of plant material including plant genetic resources.

The EPBC Act regulates access to the genetic resources of native species in Commonwealth areas in a manner consistent with the Convention on Biological Diversity. The states and territories also regulate access to their genetic resources through similar regulatory systems. The EPBC Act protects biodiversity through a system of listing nationally threatened species and ecological communities, and preparing conservation advice or recovery plans for listed species. The states and territories also have powers to list and protect threatened species in their jurisdictions. Harmonisation of the listing of threatened species and communities across the various jurisdictions has been identified as a priority in Australia's Biodiversity and Conservation Strategy 2010–2030 (Natural Resource Management Ministerial Council 2010).

The *Patents Act 1990* and the *Plant Breeder's Rights Act 1994* provide a framework for intellectual property protection for new plant varieties and patentable inventions derived from plant genetic resources.

The *Food Standards Australia New Zealand Act 1991* and the *Gene Technology Act 2000* provide regulatory systems for food safety and the safety of genetically modified organisms under research conditions or when they are released to the environment.

Seeds

Australia mostly relies on an industry self-regulation model for ensuring high-quality seed is sold to growers. The Australian Seeds Federation has developed two codes of practice:

- National Code of Practice for Seed Labeling and Marketing
- National Code of Practice for the Use of Seed Treatments.

Companies that are members of the Australian Seeds Federation and have been accredited under the codes are subject to the national *Competition and Consumer Act 2010* that regulates industry codes of practice. This Act provides for compensation to those who have sustained damage or loss as a result of a company's non-compliance to industry codes of practice. The Act also has provisions for pecuniary penalties for non-compliance to industry codes of practice.

In addition, some states have legislation that imposes more stringent requirements on seed providers than the two codes of practice mentioned above. Two states have specific seed legislation. This legislation aims to protect the state from crop diseases and weeds present in other Australian jurisdictions. Also most states have noxious weeds legislation making it illegal to sell anything containing seed of declared noxious weeds.

South Australia has legislation prohibiting the transport of genetically modified (GM) canola seed within its jurisdiction even though cultivation and transport of the GM material is allowed in adjacent states. This particular statute means that transport of GM seed across southern Australia has to occur via sea or by circuitous road transport through other jurisdictions.

7 The state of regional and international collaboration

Australia collaborates at the regional and international level in the area of plant genetic resources.

At the regional level, Australia provides financial and other support to the Secretariat of the Pacific Community which runs the Centre for Pacific Crops and Trees (CePaCT) seed bank in Fiji. CePaCT gives priority to the conservation of the region's staple crops: taro, yam, sweet potato, banana, cassava and breadfruit.

The Secretariat of the Pacific Community also formed the Pacific Agricultural Plant Genetic Resources Network (PAPGReN), with financial and technical assistance from Australia, New Zealand and Bioversity International. PAPGReN aims to promote the conservation and use of the genetic resources of crops of local importance in order to ensure long-term conservation and access to these genetic resources by Pacific island populations.

The former Australian Agency for International Development (AusAID, now integrated with the Department of Foreign Affairs and Trade) has provided funding for projects in the Pacific region that identify and evaluate CePaCT collections for climate-change tolerance traits, and work to introduce the traits into Pacific community breeding programs.

The Australian Centre for International Agricultural Research (ACIAR) has also provided funding for regional projects. These projects include work on crop improvement and sustainable use of material derived from PAPGReN and the genetic resources of CePaCT.

ACIAR provides significant resources for international projects where Australian researchers collaborate with researchers from developing countries. ACIAR also provides significant core and project funding to the International Agricultural Research Centres (IARCs) of the CGIAR. In 2012, Australia was the fourth largest donor to the CGIAR, with significant funds going to the plant-based IARCs for both core work and specific germplasm-enhancement projects.

Apart from funding and collaborating in research, Australia is involved in supporting the International Treaty on Plant Genetic Resources for Food and Agriculture and other international plant genetic resource initiatives. In 2010, Australia donated US$1 million to the Treaty's Benefit Sharing Fund and in 2013 was elected as chair of the Bureau of the Sixth Session of the Treaty's Governing Body.

In 2006, Australia ran workshops in Fiji on plant genetic resource issues and developments. Representatives from 13 Pacific Island Countries and Territories (PICTs) attended the workshop where developments relevant to the ITPGRFA were presented. Views gathered at this meeting were presented by Australia (representing the South West Pacific Region) at the first meeting of the ITPGRFA's governing body in Madrid in 2006.

In 2007, another plant genetic resources workshop was held in Fiji with 14 PICTS in attendance. The aim of this workshop was to improve awareness of the state of plant genetic resources in the region, and the benefits of participation in the ITPGRFA.

Australia has represented the South West Pacific Region on the Bureau (chair and regional vice chairs) of the Governing Body of the ITPGRFA since 2006. Australia has also donated around US$21 million to the Global Crop Diversity Trust.

Australia made its first deposit of seeds to the Svalbard Global Seed Vault in 2011. The deposit, from the Australian Genebank Grains collection in Horsham, Victoria, comprised a total of 343 pea and chickpea accessions.

Australia is a party to the Convention on Biological Diversity and has signed, but not yet ratified, a subordinate instrument: the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization. The protocol aims to establish standards for access and to ensure the fair and equitable sharing of benefits arising from the use of genetic resources. It does not duplicate or intrude on existing arrangements or discussions within the mandate of other international treaties or forums, except where such arrangements would cause serious damage or threat to biodiversity.

Australia also participates in the Commission on Genetic Resources for Food and Agriculture and is a member of the International Plant Protection Convention and the Pacific Plant Protection Organisation.

8 Access to PGRFA, sharing of benefits and farmers' rights

Access to exotic PGRFA in *ex situ* collections

Australia is a party to the International Treaty on Plant Genetic Resources for Food and Agriculture, the Convention on Biological Diversity (CBD) and has signed, but not yet ratified, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization. Australia currently has five major *ex situ* collections of exotic species of PGRFA and these are described in Chapter 4 and Table 14. Current arrangements for access to PGRFA differ among the five seed banks. However, there is one common element: any material acquired under the ITPGRFA's standard material transfer agreement (SMTA) is transferred to third parties under the SMTA.

Most of the accessions in these seed banks were acquired before the development of the Treaty and the SMTA. Material in the seed banks was acquired from a variety of sources, including the CGIAR centres. The material was also acquired both before and after 1993, meaning some material may be subject to CBD obligations. These circumstances, and the relatively independent operation of the seed banks, have resulted in a variety of access and benefit-sharing regimes operating at this time. These include:

- one seed bank transfers all material (Annex 1 species and others) under the SMTA irrespective of the date or place of acquisition of the material
- some transfer all material acquired unencumbered without restriction, while others transfer all material free for research, but ask that recipients contact the seed bank to clarify obligations if they plan to commercialise the material or derivatives from it
- one seed bank has different supply policies depending on the status of ITPGRFA ratification of the requesting country, the country where the material was acquired, and any bilateral transfer agreements covering the material.

However, the Australian PGRFA system is undergoing gradual change that will better align the operation of seed banks with international obligations. The Australian Grains Genebank, when fully operational, will transfer all material under the SMTA and formally place all accessions into the ITPGRFA's multilateral system. It is also understood that any national pastures seed bank will also use the GRIN-Global database to facilitate access, place its accessions into the multilateral system and transfer material under the SMTA.

Access to native species

Australia also has native plant species that are bush foods (Table 5 in the Appendix) and species related to those listed in Annex 1 of the ITPGRFA. While samples of some of these native species are held in the *ex situ* collections, some are also stored in a series of seed banks dedicated to the conservation of Australian flora. These native species are also found *in situ*.

Access to *ex situ* native plant material

Current and expected access arrangements for crop species and exotic and native crop relatives held in the five major seed banks are described above.

The Australian Seed Bank Partnership is a formal network of nine seed banks and five other flora-focused organisations, which aims to conserve Australia's native-plant diversity through collaborative and sustainable seed collecting, banking, research and knowledge sharing. Access regimes for all material within these seed banks depend on the jurisdiction in which the seed bank resides; however, all seed banks provide material under a material transfer agreement for revegetation activities to community groups and government organisations. They also provide seeds to institutions for research that furthers understanding of the species. Commercial use is not allowed under these agreements. If recipients later want to use the material or its derivatives commercially, some jurisdictions require the negotiation of a benefit-sharing agreement on mutually agreed terms.

If the species is listed as threatened, modes of access may also vary. For instance, for listed material under the control of the Commonwealth, a separate permit application to the Environment Minister must be made. If the permit is granted, material would be then transferred under a material transfer agreement with an access and benefit-sharing agreement in place. However, if seeds (including those of listed species) are being transferred to seed banks in other countries, no permits are required.

Access to *in situ* material

In Australia, the federal, state and territory governments have responsibility for access to *in situ* native genetic resources within their territorial jurisdiction.

In 2002, all Australian governments endorsed the Nationally Consistent Approach for Access to and the Utilisation of Australia's Native Genetic and Biochemical Resources. One of the aims of the approach is to ensure that the benefits of access are equitably shared between providers and recipients. The Australian Government has worked with state and territory governments and with its own departments and agencies to establish a common approach to genetic resource management. More information on the Nationally Consistent Approach can be found at www.environment.gov.au/biodiversity/publications/nca/index.html.

Access for both non-commercial and commercial uses of native genetic resources in Commonwealth areas requires a permit. An access permit for commercial use of genetic resources requires a benefit-sharing agreement between the applicant and the resources provider. This agreement must also acknowledge any use of traditional knowledge, and document, as appropriate, the benefit sharing arrangements associated with use of that traditional knowledge.

Sharing of benefits arising from use of PGRFA

Under the International Treaty on Plant Genetic Resources for Food and Agriculture, benefit sharing includes:

- the exchange of information
- access to and transfer of technology
- capacity building
- sharing of monetary and other benefits of commercialisation.

Sharing of some of these benefits (exchange of information and benefits of commercialisation) is facilitated by the multilateral system. Australia, as a party to the ITPGRFA, is encouraging major domestic holders of non–Commonwealth-owned PGRFA to place their holdings and associated information into the multilateral system.

While transfer of material using the SMTA has not yet generated significant revenue for the Treaty's Benefit Sharing Fund, Australia, along with other countries, has made voluntary contributions to this fund. In 2010, Australia donated US$1 million to the Benefit Sharing Fund. Australia has also donated about US$21 million to the Global Crop Diversity Trust. The trust's major focus is the rescue and conservation of threatened PGRFA, placing this material in the multilateral system and funding assessment of this conserved material for useful traits. Information from these activities is available in public databases.

Australia's R&D sector makes information available that is relevant to the conservation and use of PGRFA through publication of research results in scientific literature. Australian legislation providing plant breeders' rights encourages those owning the rights to make their material available for others to improve and develop new varieties.

As mentioned in Chapter 7, AusAID and ACIAR have provided funding for capacity building in developing countries, including in agriculture and the use of plant genetic resources for crop varieties that are better adapted to their production environments. While AusAID has concentrated on broad-spectrum development aid, ACIAR's main focus has been on capacity building in agricultural research.

There has been a shift in the way new plant varieties are developed and deployed in Australia. Several decades ago, it was common practice for state agricultural agencies to develop new plant varieties and make them freely available to farmers. However, this role has now been transferred to the private sector, with breeding and varietal development provided by many companies. Pre-breeding, the science of bringing novel traits into material breeding companies can usefully develop and deploy, is still supported by RDCs using public money and by levies on grain sales.

Farmers' rights in Australia

Australia has legislation and policy measures for matters addressed in the Treaty's treatment of farmers' rights. Australia's legislation for intellectual property protection of new plant varieties, the *Plant Breeder's Rights Act 1994*, protects and promotes the conditioning and propagation of farm-saved seed by exempting such acts from infringement of plant breeder's rights.

The Australian Government is currently engaging with stakeholders on the role of the intellectual property system in protecting traditional knowledge, and Aboriginal and Torres Strait Islander interests in food plants are being discussed. The National Vegetation Framework recognises the importance of Australian Indigenous peoples' knowledge for the management of native vegetation, including plant food species. The framework also recognises that the needs, rights and interests of Indigenous Australians should be acknowledged and included early in the planning and decision making processes.

All Australian governments have a policy commitment under the Nationally Consistent Approach for Access to and the Utilisation of Australia's Native Genetic and Biochemical Resources, in some cases backed by legislative sanctions, to ensure that the use of associated

traditional knowledge is undertaken with the cooperation and approval of the holders of that knowledge and on mutually agreed terms.

9 Contribution of PGRFA management to food security and sustainable development

Australia has a modern agriculture sector that uses new crop varieties and practices to efficiently produce considerable amounts of food for domestic consumption and export. Almost all production relies on exotic species and therefore Australian agriculture is heavily reliant on PGRFA originating in other countries. It has long been recognised that it is more efficient to import plant genetic resources and maintain the material in *ex situ* collections, than to use material once, discard it and import it again when required. For these reasons, Australia now has a substantial collection of exotic PGRFA and a modern and effective management regime to maintain and add to the collection.

Contribution to agricultural sustainability

The success of Australia's diverse plant-based agricultural industries has been underpinned by successful management of PGRFA collections. New varieties, along with developments in crop management, have resulted in gradual increases in average yield over many decades. However, Australian and global agriculture is facing pressure to increase production while significantly reducing the damaging effects agriculture has on the natural resources on which it depends.

Plant genetic resources are being used in a variety of ways to increase yields, while increasing the sustainability of production systems. For example, in Australia, the use of conservation agricultural techniques has sometimes been associated with lower yields in comparison to conventional tillage systems. Furthermore, wheat breeding is usually undertaken under conventional tillage. Trethowan and colleagues (2011) have shown variation within wheat plant genetic resources for yield under different tillage practices. This points to the possibility of breeding wheat with increased yields under conservation agriculture practices, which are widely accepted as contributing to agricultural sustainability.

Many other traits are being developed to increase the sustainability of production systems. Pest and diseases can have major impacts on crop yields and methods for their control can sometimes have unintended effects. The off-site impacts of pesticides are well known. Scientists find resistance to major crop pests and diseases in the plant genetic resources of the crop species or in wild relatives. Australia has a long standing research program utilising plant genetic resources to maintain genetic resistance to wheat-rust pathogens. Australian scientists have also used wild relatives of wheat to produce new wheat varieties that are resistant to barley yellow dwarf virus, a disease that can result in significant yield reductions. In the absence of resistance genes, the only option for control of this disease is through control of the insects that transmit the disease.

Although these examples are about increasing or maintaining yield, they also show how plant genetic resources can support more sustainable farming practices such as conservation agriculture or reduced pesticide use.

Contribution to food security

Australia has adequate quantities of high-quality food to feed its population, and uses plant genetic resources to improve varieties for Australian conditions to increase yields and domestic sustainability. In the context of global food security, Australia provides material and directions for agricultural research in countries that share the low-input, low-rainfall conditions found in most of Australia's farming zones. Examples of the contribution that use of plant genetic resources may make to food security are outlined below.

New salinity-tolerant varieties of durum wheat have been developed and released in Australia. These were developed during the late 1990s and 2000s when the nature of the salinity tolerance was investigated. Lines of durum wheat from the Australian Winter Cereals Collection at Tamworth were screened for differential salinity tolerance, along with bread wheat which is known to be relatively tolerant. One line proved to be very resistant. This line was the result of crossing experiments between durum wheat and *Triticum monococcum* carried out in 1973 and stored in the Australian Winter Cereals Collection (James et al. 2006) for 25 years. The nature of the resistance mechanism, which excludes salt from the roots, was recently reported by Munns and colleagues (2012). The use of plant genetic resources maintained in the Australian Winter Cereals Collection may increase food production in other countries through the deployment of salt-exclusion genes in cereals, and possibly other crops.

Another example is the development of wheat with longer coleoptiles (shoots). The use of semi-dwarf varieties common to the green revolution had the effect of shortening the shoots of cereals; however, longer shoots are advantageous in low rainfall agriculture. In some situations in Australia, water present in the soil before planting is thought to account for up to 70 per cent of the crop yield (Hunt & Kirkegaard 2011). Seeds with longer shoots can be planted deeper in the soil and are therefore better able to access stored soil moisture. Using long-coleoptile wheats, along with appropriate crop management and rotations, Kirkegaard and Hunt (2010) predict significant (up to 35 per cent) increases in wheat production. The development of long coleoptile material has been difficult and required the use of new sources of dwarfing genes, so that mature stems remain short but the emerging shoots grow longer than in older varieties. This has involved extensive screening of plant genetic resources collections. New varieties with long coleoptile traits are now under development and should be available in 4–5 years (John Passioura pers. comm., CSIRO, February 2013).

Other avenues to increase the use of stored soil water are being explored, including potential development of wheats with deeper root systems. Indian wheat varieties have deeper root systems than Australian varieties and there is interest in incorporating these traits into Australian wheat varieties to allow them to access stored soil moisture for increased yields.

Contribution to economic development and poverty alleviation

Economic development

The impact of plant genetic resources on Australian economic development has been, and is likely to continue to be, substantial. For example, the gross value of production from plant-based commodities in 2010–11 (see Figure 1) was about $24 billion. Brennan and Bialowas (2001) found that 54 per cent of the improvement in wheat yields in New South Wales main cropping regions from 1965 to 1997 was due to varietal improvements. When estimating the

impact of the New South Wales wheat breeding program since 1980, Brennan, Martin and Mullen (2004) use a figure of 30 per cent of yield improvement through variety development.

During the reviews of the PGRCs in the mid 2000s, an unpublished cost–benefit analysis of the proposed National Genetic Resource Centre estimated the present value of the centre's benefits over the following 30 years at around $6 billion, with half of this going to the cropping sector.

Poverty alleviation

While Australia is a rich country, some groups and individuals suffer disadvantage including financial disadvantage. Australia has a well-developed government welfare system that supports the disadvantaged with financial assistance delivered through a range of measures. Non-government organisations also provide assistance to the disadvantaged. Domestic welfare measures do not include any that involve direct action with PGRFA.

In the context of international poverty alleviation, improved management of domestic PGRFA collections and their integration into the multilateral system will improve access to and development of improved plant material for use in developing countries. This in turn may help to alleviate poverty in these countries.

Australia has well-established overseas development aid programs which aim to alleviate poverty through economic development in poorer countries. Australia also contributes to the CGIAR and its network of International Agricultural Research Centres.

Appendix

Table 1 Estimated Australian broadacre crop production, 2010–11

Crop	Production (tonnes)	Annex 1 species
Wheat	27 410 076	Y
Sugar cane	25 181 814	
Barley	7 994 720	Y
Canola	2 358 735	Y
Cotton seed	2 154 410	
Sorghum	1 934 510	Y
Oats	1 127 683	Y
Cotton lint	843 571	
Lupins	807 673	Y
Rice	723 283	Y
Chickpeas	513 388	Y
All other cereals	410 181	
Field peas	394 675	Y
Lentils	379 659	Y
Maize	356 943	Y
Triticale	355 078	Y
Faba beans	324 365	Y
Mung beans	65 247	Y
Sunflower	42 538	Y
Soybeans	29 750	
Other field beans	18 593	Y
Peanuts	18 392	
Safflower	6 056	
Hops	986	
Sesame	121	

Source: ABS agriculture statistics 2012

Table 2 Estimated Australian fruit and nut production, 2010–11

Crop	Production (tonnes)	Annex 1 species
Grapes for wine production	1 597 669	
Apples	299 778	Y
Oranges	291 223	Y
Bananas	202 751	Y
Pears (including Nashi)	123 267	
Table grapes	106 217	
Mandarins	97 871	Y
Olives	91 067	
Pineapples	83 223	
Peaches	60 514	
Nectarines	37 033	
Mangoes	36 659	
Avocados	36 233	
Almonds	34 576	
Strawberries	30 897	Y
Macadamias	28 914	
Lemons	24 789	Y
Plums and prunes	18 433	
Apricots	13 283	
Dried grapes	11 831	
Cherries	10 475	
Grapefruit	9 217	Y
Pawpaws/papaya	6 534	
Limes	5 449	Y
Kiwifruit	2 996	
Blueberries	2 903	
Passionfruit	2 548	
Walnuts	2 493	
Pecans	2 421	
Lychees	1 557	
Custard apples	1 108	
Raspberries	797	
Pistachios	730	
Guava	605	
Blackcurrants	415	
Other berries	360	
Rambutan	133	
Jackfruit	108	Y
Carambolas	46	

Source: ABS agriculture statistics 2012

Table 3 Estimated Australian vegetable production, 2008–09 and 2010–11

Vegetables	Production (tonnes) **2010–11**	**Production (t**onnes**) 2008–09**	**Annex 1 species**
Potatoes	1 128 208	1 178 534	Y
Tomatoes	301 719	440 093	
Onions	330 847	283 819	
Carrots	224 571	263 527	Y
Melons	211 898	206 731	
Lettuce	144 637	164 543	
Pumpkins	102 934	103 729	
Cabbages	–	78 075	Y
Cauliflowers	66 692	70 286	Y
Celery	–	57 804	
Sweet corn	70 808	51 609	Y
Capsicums	50 862	49 315	
Broccoli	49 112	44 420	Y
Beetroot	–	43 268	Y
Sweet potatoes	–	42 460	Y
Beans (French and runner)	32 886	27 779	Y
Zucchini and squash	–	23 989	
Asian vegetables	–	20 209	
Peas	14 208	19 179	Y
Cucumber	–	11 943	
Parsnips	–	10 146	Y
Silver beet and spinach	–	8 638	Y (beet)
Ginger	–	8 066	
Eggplant	–	7 258	Y
Leeks	–	7 019	
Asparagus	–	6 981	Y
Spring onions	–	6 820	
Swedes and turnips	–	4 470	Y
Brussels sprouts	–	3 634	Y
Snow and sugarsnap peas	–	3 137	Y
Fennel (bulb)	–	2 940	
Herbs – other	–	2 430	
Beans (butter)	–	2 256	Y
Herbs – parsley	–	2 033	
Radish	–	1 876	Y
Herbs – coriander	1 154	987	
Garlic	–	811	
Artichokes	–	277	
Okra	–	242	
Asian gourds	–	134	
Beans (snake)	–	73	Y

Source: ABS agriculture statistics 2012

Table 4 Common Australian bush foods

Latin name	Common name	Annex 1 relative
Acacia aneura	Mulga	
Acacia colei		
Acacia coriacea	Dogwood	
Acacia holosericea	Strap wattle	
Acacia kempeana	Witchetty bush	
Acacia longifolia	Golden rods	
Acacia longifolia subsp. sophorae	Coast wattle	
Acacia murrayana		
Acacia pycnantha		
Acacia retinodes		
Acacia tetragonophylla	Dead finish seed	
Acacia victoriae	Gundabluey, prickly wattle	
Acronychia acidula	Lemon aspen	
Acronychia oblongifolia	White aspen	
Acrotriche depressa	Native currant	
Adansonia gregorii	Boab	
Alpinia caerulea	Native ginger	
Antidesma bunius	Herbert River cherry	
Apium insulare	Flinders Island celery	
Apium prostratum	Sea celery	
Araucaria bidwillii	Bunya nut	
Archirhodomyrtus beckleri	Rose myrtle	
Athertonia diversifolia	Atherton almond	
Atriplex cinerea	Grey saltbush	Y
Austromyrtus dulcis	Midyim	
Backhousia citriodora	Lemon myrtle	
Backhousia myrtifolia	Cinnamon myrtle	
Billardiera cymosa	Sweet apple-berry	
Billardiera longiflora	Purple apple-berry	
Billardiera scandens	Common apple-berry	
Brachychiton populneus	Kurrajong	
Buchanania arborescens	Little gooseberry tree	
Burchardia umbellata	Milkmaids	
Calandrinia balonensis	Parakeelya	
Capparis mitchelii	Wild orange	
Capparis spinosa subsp. var. nummularia	Wild passionfruit	
Capparis spp.	Native caper, caperbush	
Carissa lanceolata	Bush plum, conkerberry	
Carpobrotus glaucescens	Pigface	
Carpobrotus rossii	Karkalla	
Citrus australasica	Finger lime	Y
Citrus australis	Dooja	Y
Citrus glauca	Desert lime	Y
Citrus gracilis	Kakadu lime	Y
Commelina cyanea	Scurvy weed	
Cycas media	Cycad palm seeds (require detoxification)	
Davidsonia jerseyana	New South Wales Davidson's plum	
Davidsonia johnsonii	Smooth davidsonia	
Davidsonia pruriens	North Queensland Davidson's plum	
Dioscorea alata	Chinese or winged yam	
Dioscorea bulbifera	Round yam	
Dioscorea transversa	Pencil yam, long yam	
Diploglottis campbellii	Small-leaf tamarind	
Eleocharis spp.	Mat-rush, a staple	
Enchylaena tomentosa	Ruby saltbush	
Eucalyptus dives	Peppermint gum	
Eucalyptus globulus	Tasmanian blue gum	

Latin name	Common name	Annex 1 relative
Eucalyptus olida	Strawberry gum	
Eucalyptus polybractea	Blue-leaved mallee	
Eucalyptus staigeriana	Lemon ironbark	
Eugenia reinwardtiana	Cedar Bay cherry	
Eupomatia laurina	Bolwarra	
Eustrephus latifolius	Wombat berry	
Exocarpos cupressiformis	Native cherry	
Ficus coronata	Sandpaper fig	
Ficus platypoda	Desert fig	
Ficus racemosa	Cluster fig	
Gaultheria hispida	Snow berry	
Geitonoplesium cymosum	Scrambling lily	
Ipomoea aquatica	Native kang kong	Y
Ipomoea costata	Bush potato	Y
Kunzea pomifera	Muntries	
Lepidium spp.	Peppercresses	
Leptospermum liversidgei	Lemon tea-tree	
Macadamia integrifolia	Macadamia nut	
Macadamia tetraphylla	Bush nut	
Manilkara kaukii	Wongi	
Marsdenia australis	Doubah, bush banana	
Melaleuca leucadendra	Weeping paperbark	
Melaleuca viridiflora	Kitcha-kontoo	
Melastoma affine	Blue tongue	
Melodorum leichhardtii	Zig zag vine	
Mentha australis	River mint	
Microseris scapigera	Murnong	
Mimusops elengi	Tanjong	
Morinda citrifolia	Noni	
Nelumbo nucifera	Lotus	
Nymphaea macrosperma	Water lily	
Ocimum tenuiflorum	Native basil	
Owenia acidula	Emu apple	
Panicum decompositum	Native millet	
Physalis minima	Native gooseberry	
Planchonella australis	Black apple	
Pleiogynium timoriense	Burdekin plum	
Podocarpus elatus	Illawarra plum	
Portulaca intraterranea	Large pigweed	
Portulaca oleracea	Pigweed	
Prostanthera incisa	Cut-leaf mintbush	
Prostanthera rotundifolia	Native thyme	
Rubus moluccanus	Broad-leaf bramble	
Rubus parvifolius	Pink-flowered native raspberry	
Rubus probus	Atherton raspberry	
Rubus rosifolius	Rose-leaf bramble	
Sambucus gaudichaudiana	White elderberry	
Santalum acuminatum	Quandong, desert or sweet quandong	
Santalum murrayanum	Bitter quandong	
Semecarpus australiensis	Australian cashew	
Smilax glyciphylla	Sweet sarsaparilla	
Solanum centrale	Akudjura, Australian desert raisin, bush tomato	Y
Solanum cleistogamum	Bush tomato	Y
Solanum ellipticum	Bush tomato	Y
Sterculia quadrifida	Peanut tree	
Syzygium anisatum	Aniseed myrtle	
Syzygium australe	Brush cherry	
Syzygium erythrocalyx	Johnstones River satinash	
Syzygium fibrosum	Fibrous satinash	

Latin name	Common name	Annex 1 relative
Syzygium luehmannii	Riberry	
Syzygium paniculatum	Magenta lilly pilly	
Syzygium suborbiculare	Lady apple	
Tasmannia lanceolata	Mountain pepper	
Tasmannia stipitata	Dorrigo pepper (leaf and pepperberry)	
Terminalia catappa	Sea almond	
Terminalia ferdinandiana	Kakadu plum	
Tetragonia tetragonioides	Warrigal greens	
Trachymene incisa	Wild parsnip	
Triodia spp.	Commonly known as spinifex	
Urtica incisa	Scrub nettle	
Vigna lanceolata	Pencil yam	Y
Ximenia americana	Yellow plum	

Note: Annex 1 species are identified in by a Y in the relevant column.

Source:http://en.wikipedia.org/wiki/Bushfood#Native_Australian_food plants_listed_by_culinary_province_and_plant_part

Table 5 Varieties in the 2012 National Variety Trials

Crop	Commercial varieties	Varieties nearing commercial release
Barley	38	6
Canola	58	16
Chickpea	18	5
Faba bean	8	0
Field pea	10	3
Lentil	9	1
Lupin	13	0
Oat	13	1
Triticale	17	0
Wheat	99	15

Note: Data from Alan Bedggood, Manager, National Variety Trials

Table 6 Range of pasture and fodder species recommended for use across a range of Australian production environments

Species	Common name	Annex 1
Aeschynomene americana	American jointvetch	
Aeschynomene villosa	Villose jointvetch	
Arachis pintoi	Pinto peanut	
Astrebla spp	Mitchell grass	
Atriplex amnicola	River saltbush	
Atriplex halimus	Mediterranean saltbush	Y
Atriplex nummularia	Old man saltbush	Y
Atriplex semibaccarta	Creeping saltbush	
Avena sativa	Forage oats	Y
Biserrula pelecinus	Biserrula	
Bothriochloa bladhii subsp. glabra	Forest bluegrass	
Bothriochloa insculpta	Creeping bluegrass	
Bothriochloa pertusa	Indian bluegrass	
Brassica campestris var. rapa	Turnip	Y
Brassica napus ssp. napobrassica	Swede	Y
Brassica napus var. napus; Raphanus sativus; Brassica interspecific crosses	Rape, radish and hybrid rape	Y
Brassica oleracea ssp.var. acephala	Kale	Y
Bromus catharticus	Prairie grass	
Bromus spp.	Grazing bromegrass	

Species	Common name	Annex 1
Cenchrus ciliaris	Buffel grass	
Cenchrus clandestinum	Kikuyu	
Cenchrus glaucum	Pearl millet, bullrush millet	
Cenchrus pennisetiformis	Cloncurry buffel grass	
Centrosema brasilianum	Brazilian centro	
Centrosema molle	Centro	
Centrosema pascuorum	Centurion	
Chamaecrista rotundifolia	Roundleaf cassia, wynn cassia	
Chamaecytisus prolifer var. palmensis	Tagasaste, tree lucerne	
Chloris gayana	Rhodes grass	
Cichorium intybus	Chicory	
Clitoria ternatea	Butterfly pea	
Cullen australasicum	Native scurf pea	
Dactylis glomerata	Cocksfoot	Y
Desmanthus virgatus	Desmanthus	
Desmodium intortum	Greenleaf desmodium	
Desmodium uncinatum	Silverleaf desmodium	
Dichanthium aristatum	Angleton grass	
Dichanthium sericeum	Queensland bluegrass	
Digitaria eriantha	Digit grass or pangola grass	
Digitaria milanjiana	Tall finger grass	
Echinochloa polystachya	Aleman grass	
Echinochloa spp.	Millets	
Ehrharta calycina	Perennial veldt grass	
Enchylaena tomentosa	Ruby saltbush	
Eragrostis curvula	African lovegrass	
Festuca arundinacea	Tall fescue	Y
Hedysarum coronarium	Sulla	Y
Lablab purpureus	Lablab	
Leucaena leucocephala	Leucaena	
Lolium boucheanum/multiflorum	Hybrid/biennial ryegrass	
Lolium multiflorum	Italian/annual ryegrass	Y
Lolium perenne	Perennial ryegrass	Y
Lolium rigidum	Wimmera/annual ryegrass	Y
Lophopyrum ponticum	Tall wheat grass	
Lotononis bainesii	Lotononis	
Lotus corniculatus	Birdsfoot trefoil	Y
Lotus uliginosus	Greater lotus	Y
Lupinus consentinii	Blue lupin	
Macroptilium atropurpureum	Siratro	
Macroptilium bracteatum	Burgundy bean	
Mareana brevifolia	Small leaf bluebush	
Medicago littoralis	Strand medic	
Medicago orbicularis	Button medic	
Medicago polymorpha var. brevispina	Spineless burr medic	
Medicago rugosa	Gama medic	
Medicago sativa	Lucerne	Y
Medicago scutellata	Snail medic	Y
Medicago sphaerocarpus	Sphere medic	
Medicago tornata	Disc medic	
Medicago tornata x Medicago littoralis hybrid	Hybrid disc medic	
Medicago truncatula	Barrel medic (*Medicago truncatula*)	Y
Melilotus albus	Bokhara clover (*Melilotus albus*)	Y
Neonotonia wightii	Glycine	
Oenothera stricta	Evening primrose	
Ornithopus compressus	Yellow serradella	
Ornithopus pinnatus	Slender serradella	
Ornithopus sativus Brot	French serradella – hard seeded	Y
Ornithopus sativus Brot	French serradella – soft seeded	Y

Species	Common name	Annex 1
Panicum coloratum	Bambatsi panic	
Panicum maximum	Guinea grass	
Panicum maximum	Panics	
Paspalum nicorae	Brunswick grass	
Phalaris aquatica	Phalaris	Y
Phleum pratense	Timothy	Y
Plantago lanceolata	Plantain	
Puccinellia ciliata	Puccinellia	
Setaria incrassata	Purple pigeon grass	
Setaria sphacelata	Setaria	
Sorghum	Annual forage sorghum	Y
Sorghum spp.	Perennial forage sorghum, 'silk' sorghum	Y
Stylosanthes guianensis var. guianensis	Stylo	
Stylosanthes guianensis var. intermedia	Fine stem stylo	
Stylosanthes hamata	Stylo, Caribbean stylo	
Stylosanthes scabra	Shrubby stylo	
Stylosanthes seabrana	Caatinga stylo	
Trifolium alexandrinum	Berseem clover	Y
Trifolium ambiguum	Caucasian clover	Y
Trifolium dasyurum	Eastern star clover	
Trifolium fragiferum	Strawberry clover	
Trifolium glanduliferum	Gland clover	
Trifolium hirtum	Rose clover	
Trifolium hybridum	Alsike clover	Y
Trifolium incarnatum	Crimson clover	Y
Trifolium michelianum	Balansa clover	
Trifolium pratense	Red clover	Y
Trifolium purpureum	Purple clover	
Trifolium repens	White clover	Y
Trifolium resupinatum var. majus	Persian clover	Y
Trifolium resupinatum var. resupinatum	Persian clover	Y
Trifolium spumosum	Bladder clover	
Trifolium subterraneum ssp. brachycalycinum	Subterranean/sub clover	Y
Trifolium subterraneum ssp. subterraneum	Subterranean/sub clover	Y
Trifolium subterraneum ssp. yanninicum	Subterranean/sub clover/white seeded	Y
Trifolium tumens	Talish clover	
Trifolium vesiculosum	Arrowleaf clover	Y
Urochloa brizantha	Brizantha	
Urochloa decumbens	Signal grass	
Urochloa humidicola	Humidicola	
Urochloa mosambicensis	Sabi grass	
Urochloa mutica	Para grass	
Urochloa spp. hybrids	Brachi hybrid, brachiaria hybrid	
Vicia benghalensis	Purple vetch	Y
Vicia sativa	Common vetch	Y
Vicia villosa ssp. dasycarpa	Woolly pod vetch	Y
Vigna parkeri	Creeping vigna	Y
Vigna unguiculata	Cowpea	Y
Zea mays	Maize	Y

Source: Pastures Australia (2013)

Table 7 Australian native *Cajanus* species

Species	Species
Cajanus acutifolius	*Cajanus marmoratus*
Cajanus aromaticus	*Cajanus pubescens*
Cajanus cinereus	*Cajanus reticulatus*
Cajanus confertiflorus	*Cajanus reticulatus var. grandifolius*
Cajanus crassicaulis	*Cajanus reticulatus var. maritimus*
Cajanus geminatus	*Cajanus reticulatus var. reticulatus*
Cajanus hirtopilosus	*Cajanus scarabaeoides*
Cajanus lanceolatus	*Cajanus scarabaeoides var. pedunculatus*
Cajanus lanuginosus	*Cajanus scarabaeoides var. scarabaeoides*
Cajanus latisepalus	*Cajanus viscidus*

Source: Australian Plant Census and van der Maeson (2003)

Table 8 Australian native *Citrus* species

Species	Species
Citrus australasica	*Citrus glauca*
Citrus australis	*Citrus gracilis*
Citrus garrawayi	*Citrus inodora*

Source: Australian Plant Census

Table 9 Australian native *Dioscorea* species

Species	Species
Dioscorea alata	*Dioscorea pentaphylla*
Dioscorea bulbifera var. bulbifera	*Dioscorea pentaphylla var. papuana*
Dioscorea bulbifera var. elongata	*Dioscorea transversa*
Dioscorea hastifolia	

Source: Australian Plant Census

Table 10 Australian native *Ipomoea* species

Species	Species
Ipomoea abrupta	*Ipomoea obscura*
Ipomoea aculeata	*Ipomoea pes-caprae subsp. brasiliensis*
Ipomoea antonschmidii	*Ipomoea plebeia*
Ipomoea aquatica	*Ipomoea polpha subsp. latzii*
Ipomoea argillicola	*Ipomoea polpha subsp. polpha*
Ipomoea brassii	*Ipomoea polpha subsp. weirana*
Ipomoea brownii	*Ipomoea polymorpha*
Ipomoea calobra	*Ipomoea racemigera*
Ipomoea coptica	*Ipomoea saintronanensis*
Ipomoea costata	*Ipomoea sp. A Kimberley Flora*
Ipomoea diamantinensis	*Ipomoea sp. Cobourg*
Ipomoea diantha	*Ipomoea sp. Kalumburu*
Ipomoea diversifolia	*Ipomoea sp. Mungana*
Ipomoea eriocarpa	*Ipomoea sp. Nindigully*
Ipomoea gracilis	*Ipomoea sp. OT Station*
Ipomoea graminea	*Ipomoea sp. Ramingining*
Ipomoea hastifolia	*Ipomoea sp. Tolmer*
Ipomoea littoralis	*Ipomoea stolonifera*
Ipomoea lonchophylla	*Ipomoea tiliacea*
Ipomoea macrantha	*Ipomoea trichosperma*
Ipomoea mauritiana	*Ipomoea velutina*
Ipomoea muelleri	*Ipomoea yardiensis*

Source: Australian Plant Census

Table 11 Australian native *Musa* (banana) species

Species
Musa banksii
Musa fitzalanii
Musa jackeyi

Note: *Musa fitzalanii* presumed to be extinct. Source: Australian Plant Census

Table 12 Australian native *Oryza* species

Species	Species
Oryza australiensis	*Oryza officinalis*
Oryza meridionalis	*Oryza rufipogon*
Oryza minuta	

Source: Australian Plant Census

Table 13 Australian native *Solanum* species

Species	Species
Solanum acanthodapis	*Solanum lachnophyllum*
Solanum adenophorum	*Solanum laciniatum*
Solanum amblymerum	*Solanum lacunarium*
Solanum americanum	*Solanum lasiocarpum*
Solanum ammophilum	*Solanum lasiophyllum*
Solanum angustum	*Solanum latens*
Solanum argopetalum	*Solanum leopoldense*
Solanum armourense	*Solanum limitare*
Solanum ashbyae	*Solanum linearifolium*
Solanum asymmetriphyllum	*Solanum longissimum*
Solanum aviculare	*Solanum lucanii*
Solanum beaugleholei	*Solanum lythrocarpum*
Solanum brownii	*Solanum macoorai*
Solanum campanulatum	*Solanum magnifolium*
Solanum capsiciforme	*Solanum melanospermum*
Solanum carduiforme *	*Solanum mentiens*
Solanum cataphractum	*Solanum mitchellianum*
Solanum celatum	*Solanum multiglochidiatum*
Solanum centrale	*Solanum nemophilum*
Solanum chenopodinum	*Solanum neoanglicum*
Solanum chippendalei	*Solanum nobile*
Solanum cinereum	*Solanum nummularium*
Solanum clarkiae	*Solanum oedipus*
Solanum cleistogamum	*Solanum oldfieldii*
Solanum coactiliferum	*Solanum oligacanthum*
Solanum cocosoides	*Solanum oligandrum*
Solanum cookii	*Solanum opacum*
Solanum coracinum	*Solanum orbiculatum*
Solanum corifolium	*Solanum orbiculatum subsp. macrophyllum*
Solanum crassitomentosum	*Solanum orbiculatum subsp. orbiculatum*
Solanum crebrispinum	*Solanum orgadophilum*
Solanum cunninghamii	*Solanum papaverifolium*
Solanum curvicuspe	*Solanum parvifolium + subsp.*
Solanum defensum	*Solanum petraeum*
Solanum densevestitum	*Solanum petrophilum*
Solanum dianthophorum	*Solanum phlomoides*
Solanum dimorphispinum	*Solanum pisinnum*
Solanum dioicum	*Solanum plicatile*
Solanum discolor	*Solanum prinophyllum*
Solanum dissectum	*Solanum pugiunculiferum*
Solanum ditrichum	*Solanum pungetium.*
Solanum diversiflorum	*Solanum pusillum*
Solanum dryanderense	*Solanum quadriloculatum*

Species	Species
Solanum dumicola	*Solanum rixosum*
*Solanum dunalianum**	*Solanum sejunctum*
Solanum dysprosium	*Solanum semiarmatum*
Solanum eardleyae	*Solanum senticosum*
Solanum eburneum	*Solanum serpens*
Solanum echinatum	*Solanum shirleyanum*
Solanum elachophyllum	*Solanum silvestre*
Solanum ellipticum + subsp.	*Solanum simile*
Solanum eminens	*Solanum sp. Bachsten Creek*
Solanum eremophilum	*Solanum sp. Boomerang Bay*
Solanum esuriale	*Solanum sp. Litchfield*
Solanum ferocissimum	*Solanum sp. Longini*
Solanum ferox	*Solanum sp. Mt Brockman*
Solanum fervens	*Solanum sp. Prince Regent River*
Solanum francisii	*Solanum spirale*
Solanum furfuraceum	*Solanum sporadotrichum*
Solanum gabrielae	*Solanum stelligerum*
Solanum galbinum	*Solanum stenopterum*
Solanum gilesii	*Solanum stupefactum*
Solanum graniticum	*Solanum sturtianum*
Solanum gympiense	*Solanum succosum*
Solanum hamulosum	*Solanum symonii*
Solanum hapalum	*Solanum terraneum*
Solanum hesperium	*Solanum tetrandrum*
Solanum heteropodium	*Solanum tetrathecum*
Solanum hoplopetalum	*Solanum tudununggae*
Solanum horridum	*Solanum tumulicola*
Solanum hystrix	*Solanum ultimum*
Solanum inaequilaterum	*Solanum vansittartense*
Solanum innoxium	*Solanum versicolor*
Solanum intonsum	*Solanum vescum*
Solanum johnsonianum	*Solanum vicinum*
Solanum jucundum	*Solanum viridifolium*
*Solanum karsense **	*Solanum yirrkalense*

Source: Australian Plant Census and Barker (2010)

Table 14 Australian native *Sorghum* species

Species	Species
Sorghum amplum	*Sorghum macrospermum*
Sorghum angustum	*Sorghum matarankense*
Sorghum brachypodum	*Sorghum nitidum.*
Sorghum bulbosum	*Sorghum nitidum f. aristatum.*
Sorghum ecarinatum	*Sorghum nitidum f. nitidum*
Sorghum exstans	*Sorghum plumosum*
Sorghum grande	*Sorghum plumosum var. plumosum*
Sorghum interjectum	*Sorghum plumosum var. teretifolium*
Sorghum intrans	*Sorghum stipoideum*
Sorghum laxiflorum	*Sorghum timorense*
Sorghum leiocladum	

Source: Australian Plant Census

Table 15 Australian native *Vigna* species

Species	Species
Vigna canescens	*Vigna sp. Station Creek*
Vigna lanceolata	*Vigna sp. central*
Vigna lanceolata var. filiformis	*Vigna sp. northern pubescent*
Vigna lanceolata var. lanceolata	*Vigna sp. rockpiles*
Vigna lanceolata var. latifolia	*Vigna suberecta*
Vigna marina	*Vigna unguiculata*
Vigna radiata	*Vigna vexillata*
Vigna savi	*Vigna vexillata var. angustifolia*
Vigna sp. Greta Creek	*Vigna vexillata var. vexillata*
Vigna sp. Hamersley Clay	*Vigna vexillata var. youngiana*
Vigna sp. McDonald Downs Station	

Source: Australian Plant Census

Table 16 Details of cereal and forage holdings in Australian plant genetic resource centres

Accession type	Unit	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton, Victoria	Launceston, Tasmania	Barley, UWA
Annex 1	No.	58 713	28 599	17 462	17 240	12 791	8 722	2 322	14 240
Total	No.	63 239	29 341	40 667	45 718	17 506	29 365	4 663	14 240

Crop	Genera	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton, Victoria	Launceston, Tasmania	Barley, UWA
Breadfruit	*Artocarpus*								
Asparagus	*Asparagus*								
Oat	*Avena*	4 510			7		2	3	
Beet	*Beta*				6				
Brassica	*Brassica et al.*		4 890		40		3 210	4	
Pigeon pea	*Cajanus*			581					
Chickpea	*Cicer*		6 399		190			17	
Citrus	*Citrus*								
Coconut	*Cocos*								
Major aroids	*Colocasia,*								
Carrot	*Daucus*				1				
Yams	*Dioscorea*								
Finger millet	*Eleusine*				26		8		
Strawberry	*Fragaria*								
Sunflower	*Helianthus*			1 430	38				
Barley	*Hordeum*	14 740			80				14 240
Sweet potato	*Ipomoea*				2				
Grass pea	*Lathyrus*		549		See forages		See forages		
Lentil	*Lens*		4712		150			29	
Apple	*Malus*								
Cassava	*Manihot*								
Banana/ plantain	*Musa*								
Rice	*Oryza*			1 560					
Pearl millet	*Pennisetum*			258	11		7		
Beans	*Phaseolus*			3 342	40		1	15	
Pea	*Pisum*		5 851		57			2	
Rye	*Secale*				6		14	5	
Potato	*Solanum*				3				

Crop	Genera	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton, Victoria	Launceston, Tasmania	Barley, UWA
Eggplant	*Solanum*								
Sorghum	*Sorghum*			5 511	4				
Triticale	*Triticosecale*	978							
Wheat	*Triticum et al.*	38 485			37		39	24	
Faba bean/vetch	*Vicia*		3 499		747		21	182	
Cowpea et al.	*Vigna*			3 270	9				
Maize	*Zea*			1 064					

Forages–legumes	Species in Annex 1	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania	Barley, UWA
Astragalus	3				22 (880)		3 (4)	6 (17)	
Canavalia	1								
Coronilla	1				0 (80)	23 (1)	1	69 (8)	
Hedysarum	1				173 (113)		8	16 (5)	
Lathyrus	5				69 (138)	0 (10)	0 (2)	25 (109)	
Lespedeza	3				6	19	7 (1)	4 (4)	
Lotus	3			36*	723 (1 285)	0 (8)	34 (76)	80 (318)	
Lupinus	3		3256		25 (23)	3 655 (4 737)	0 (3)	104 (143)	
Medicago	6				10 928 (16 977)		154 (78)	166 (118)	
Melilotus	2				259 (365)		25 (8)	13 (8)	
Onobrychis	1				201 (314)		3		
Ornithopus	1				33 (151)	200 (2 980)	22 (60)	30 (57)	
Prosopis	5								
Pueraria	1				1				
Trifolium	15				2029 (3 037)	8 894 (5 081)	1 150 (16 346)	721 (757)	
Forages–grass									
Andropogon	1			410*	0 (1)				
Agropyron	2	47			60 (21)		0 (5)	10 (140)	
Agrostis	2				17 (35)		1 (14)		
Alopecurus	1				0 (12)			4 (2)	
Arrhenatherum	1				3			6	

Forages–legumes	Species in Annex 1	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania	Barley, UWA
Dactylis	1				187 (5)		674 (7)	190 (43)	
Festuca	6				303 (7)		3127 (21)	205 (24)	
Lolium	5				195 (7)		3159 (49)	332 (7)	
Phalaris	2				120 (32)		338 (11)	42 (9)	
Phleum	1				12 (10)		15	14 (1)	
Poa	3				14 (26)		1 (2)	4 (39)	
Tripsacum	1								
Forages–other									
Atriplex	2				406 (12)		0 (1)		
Salsola	1								

Note: For the forage collections, the first entry indicates the number of accessions of the species listed in Annex 1 of the ITPGRFA and the number in brackets represents the number of accessions in the same genera that do not fall under the Annex 1.

* Indicates number of accessions at the genus level as species information was not available.

Table 17 Details of non–Annex 1 holdings in Australian plant genetic resources centres

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Abutilon				7			
Acacia				106		1	1
Achnatherum				1			
Adenocarpus				1			
Adesmia				22			
Adonis				1			
Aegilops	998			55			
Aegilotriticum	2						
Aeluropus				19			5
Aeschynomene			437				
Ajuga				1			
Albizia						1	
Alectryon				5			
Alhagi				1			
Allium				12			
Allocasuarina				11			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Amaranthus							60
Amorpha							12
Amphibromus				3			
Amphipogon				3			
Andropogon				1			
Anemocarpa				1			
Angelica							2
Anthospermum				1			
Anthyllis				57			20
Aotus						4	
Apios							3
Arachis					2		
Argyranthemum				1			
Argyrolobium				22			
Aristida				10			1
Arrhenatherum				3			6
Asclepias				1			
Aspalathus				1			
Asperula				1			
Asphodelus				5			
Astragalus							23
Astrebla				19			
Astrodanthonia						1	
Astrostipa						1	
Atalaya				1			
Australopyrum	1						
Austrlopyron							10
Austrodanthonia				43		10	
Austrostipa				48			
Baptisia							4
Bassia				2			
Billardiera				1			
Biserrula					260	3	4
Bituminaria				21		7	
Boerhavia				1			
Bossiaea				5		12	
Bothriochloa			202	11		9	1

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Bouteloua				1			1
Brachiaria						2	
Brachychiton				4			
Brachypodium				11			2
Brachyscome				7			
Briza				1			
Bromus				228		51	183
Bulbine				2			
Bursaria				3			
Cakile				2			
Calamagrostis				1			
Calamovilfa				5			
Calliandra							2
Calligonum				1			
Calotis				9			
Capparis				1			
Caragana				11			
Carex				2			
Carpobrotus				2			
Carrichtera				1			
Carthamus		427		1			
Cassia				1			11
Casuarina				4			
Ceanothus							7
Cenchrus			454	18		1	
Centrosema			835	2			
Ceratonia				4			
Cercocarpus							2
Chamaecrista							2
Chamaecytisus				1			5
Chenopodium				26			24
Chicorium				150	1	23	6
Chloris			111	38		6	1
Chorilaena				1			
Chorizema						1	
Chrysocephalum				4			
Chrysopogon				1			3

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Clamagrostis						1	
Clematis				3			
Colutea				3			
Compeditor						1	
Convolvulus				9			
Cratystylis				4			
Crithopsis				1			
Crotalaria				8	11		9
Ctenium							1
Cullen				184	7	9	
Cutandia				2			
Cyamopsis				4			
Cymbopogon				11			
Cynodon			58	22		7	1
Cynosurus				2			1
Cyperus				3			
Cytisus				4			1
Dactylis							233
Dactyloctenium				24		3	
Danthonia				3		1	16
Dasypyrum				6			
Daviesia				16		14	
Deschampsia				9		1	
Desmanthus			448	20	8		1
Desmodium			1075	10			3
Deuxyia							3
Dianella				7			
Dichanthium			112	11		3	
Dichelachne				3			2
Dichondra				1			
Dichopogon				4			
Dicrastylis				1			
Digitaria			414	9		5	16
Dillwynia				4		10	
Disphyma				1			
Dissocarpus				1			
Distichlis				7			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Dolichos						1	11
Dorycnium				43	69	6	109
Dystaenia						1	
Ebenus				1			
Echinacea							2
Echinopogon				2			
Ehrharta				45		4	4
Einadia				13			
Eleusine						8	
Elymus				117		7	14
Elytrigia				40			3
Enchylaena				12			
Enneapogon				38			
Ephedra				1			
Epilobium							1
Eragrostis				31		4	1
Eremophila				45			
Erhata							1
Eriachne				5			
Erigeron							1
Eriochloa				2			
Eriogonum							3
Erodium				1			
Erophaca				4			
Eulalia				3			
Eurotia							1
Eutaxia				10		5	
Exocarpos				1			
Fagopyrum							2
Felicia				1			
Fraxinus				3			
Galactia				2			
Galega				3	9	21	2
Gastrolobium				2		1	
Gaudinia				1			
Gaultheria							1
Geijera				11			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Genista				3			6
Glycerhiza						1	
Glycine				146	4	111	13
Glycyrrhiza				56	3		2
Gnephosis				1			
Gomphocarpus				1			
Gompholobium				1			1
Goodenia				3			
Goodia				9		3	
Gossypium				14			
Grevillea				1			
Gunniopsis				1			
Hakea				1			
Halimodendron				4			
Halosarcia				2			
Hardenbergia				9		3	
Hedysarum				286			
Hemarthria				5			
Heracleum				1			
Hermannia				5			
Hibiscus				1			
Hippocrepis				154		1	2
Hoffmannseggia							1
Holcus				1		3	
Hovea						4	
Hymenocarpos				180	46	1	
Hyparrhenia				1			
Indigofera				23		9	1
Isatis				1			
Iseilema				1			
Isotropis				1		1	
Jacksonia						1	
Jasminum				1			
Jatropha				2			
Joycea				1			
Juncus				1			
Katambora						1	

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Keckiella							1
Kennedia				44	10	12	
Kochia				1			1
Koeleria						1	
Kummerowia				6			
Lablab				6			
Lachnagrostis				10			
Lawrencia				3			
Lebeckia				2			
Leiocarpa				1			
Leptochloa				7			
Leptorhynchos				2			
Lessertia				3		4	
Leymus				61		2	
Limeum				1			
Limnanthes						17	
Linum		337					
Lomandra				6			
Lothopyron						1	
Lotononis				2	30	1	1
Lycium							1
Lymus							1
Maachia							1
Macroptilium				4			5
Maireana				77			
Malacocera				1			
Malva				5			
Megathyrsus			289				1
Melaleuca				5			
Melinis				2			
Microlaena				6		9	2
Micropyrum						1	
Mimulus				1			
Minuria				7			
Mirbelia						1	
Miscanthos							1
Monachather				2			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Muhlenbergia							2
Myoporum				5			
Nassella				1			
Nemcia						1	
Nenax				2			
Neonotonia				2			
Neptunia				2			
Neurachne				2			
Newcastelia				1			
Nitraria				6			
Oenothera				1			
Olearia				4			
Ononis				35		2	
Oreophysa				1			
Oryzopsis							1
Osteospermum				1			
Otholobium				3			
Ottleya				2			
Owenia				1			
Oxylobium				1		1	
Oxytropis				1			4
Pachyrhizus							4
Paeonia				1			
Pandorea				1			
Panicum			394	24		7	2
Papaver				1			
Parochetus							1
Pascopyrum	6			7		15	
Paspalidium				1			
Paspalum			242	42			
Patersonia				1			
Pelargonium				2			
Pennisetum						7	
Periploca				2			
Petalostemon							2
Petalostylis				1			
Phacelia				1			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Phebalium				2			
Phragmites				6			
Piptatherum				11			
Piptochaetium				1			
Plantago				87		21	7
Platylobium				1		3	
Pluchea				1			
Podalryia							1
Podolepis				2			
Polypogon				1			
Pomax				1			
Portulaca				2			
Psathyrostachys				33		8	12
Pseudoroegneria						1	1
Psophocarpus							1
Psoralea							2
Pterocaulon				3			
Pteronia				1			
Ptilotus				72	9		
Puccinellia				61		22	
Pultenaea				18		26	
Purshia							1
Ranunculus				1			
Redfieldia				1			
Rhagodia				34			
Rhodanthe				2			
Rhynchosia				3	2		
Roegneria				1			
Rumex				7			
Rutidosis				1			
Salicornia				1			
Sanguisorba				21	11	2	
Santalum				2			
Sarcocornia				1			
Scaevola				4			
Schedonorus							5
Schoenoplectus				1			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Sclerolaena				4			
Scorpiurus				288		5	
Securigera				63			1
Senecio				4			
Senna				64		3	
Sesbania				9	2	1	
Setaria			377	5		4	
Sida				19			
Silphium				1			
Simmondsia				8			
Sphaerophysa				3			
Sporobolus				24		10	2
Squamatus						1	
Stachys				1			
Stackhousia				3			
Stemodia				1			
Stenotaphrum				2			
Stevia				1			
Stipa				3			7
Strophostyles							1
Stylosanthes			1 962	5	4		
Styphnolobium				1			
Suaeda				1			
Sutherlandia				4	1		1
Swainsona				122	17	8	
Taeniatherum				1			
Teline				1			16
Templetonia				12		2	
Tephrosia				5	1	1	1
Tetrachne							1
Tetragonolobus					1	3	2
Teucrium				1			
Themeda				36		4	3
Thermopsis							5
Thinopyrum	9			22		38	3
Thyridolepis				3			
Torilis				1			

Genus	AWCC, Tamworth	ATFCC, Horsham	ATCFC, Biloela	AMGRC, Adelaide	ATGRC, Perth	Hamilton Victoria	Launceston, Tasmania
Tribolium				1			
Trichanthodium				1			
Trichodesma				1			
Tricoryne				1			
Trigonella				655	63	10	9
Triodia				8			
Tripodion				8			
Triraphis				1			
Trisetobromus				4			
Tulipa				4			
Urochloa			199			1	
Viminaria				4		4	
Vittadinia				9			
Vulpia						2	
Waitzia				2			
Walafrida				1			
Westringia				1			
Wiborgia				1			
Wurmbea				1			
Ziziphora				2			
Zoysia				10			
Zygochloa				2			
Zygophyllum				7			

Table 18 Other collections of plant genetic resources for food and agriculture

State	Location	Currency of information	Plant group (accessions)	Type of collection	Annex 1 species	Notes
Australian Capital Territory	CSIRO, Black Mountain	2012	Glycine Native cotton	Seed and herbarium	No	Herbarium activities only
New South Wales	Glen Innes Agricultural Research and Advisory Station (ARAS)	2007	Perennial temperate and tropical forages (*Trifolium*, *Festuca* and tropical grasses)	Seed	Yes	National breeding station for white clover and tall fescue
New South Wales	Yanco Field ARAS Dareton ARAS Gosford ARAS	2007	Wild citrus at Yanco Citrus at Dareton and Gosford (500 accessions)	Field collection and seeds	Yes	
New South Wales	Yanco ARAS	2012	Rice (mostly japonica) (1400 accessions)	Seed	Yes	Yanco is the major Australian rice breeding centre
New South Wales	Alstonville, Centre for Tropical Horticulture	2007	Subtropical fruits and nuts (127 accessions)	Field and seed	Unknown	
New South Wales	Bathurst Primary Industries centre	2007	Stone fruit (37accessions) Hazelnuts, figs and feijoas	Field		
New South Wales	Orange Agricultural Institute	2007	Pome fruit (363 accessions)	Field	Yes (*Malus*)	
Northern Territory	Berrimah Farm, Darwin	2007	Cashew, durian, mango, rambutan (147 accessions in total)		No	
Queensland	South Johnstone Research Station	2012	Banana (200)	Field collection	Yes	Two native species. No distributions
Queensland	Maroochy Research Facility, Nambour	2012	Banana (417)	*In vitro*, disease free	Yes	Active distribution to industry (5 115 in 2012)
Queensland	Maroochy Research Facility, Nambour	2012	Pineapple (273)	Field collection	No	Mainly *Ananas comosus* – in-house breeding use
Queensland	Bundaberg Research Station	2012	Native citrus (12 accessions, 5 species)	Field collection	Yes	Distribution as seed only
Queensland	Ayr, Southedge and Walkamin Research Stations	2012	Mango Ayr (290 accessions, 7 species)	Field collection	No	All accession will be consolidated at Walkamin Station by

State	Location	Currency of information	Plant group (accessions)	Type of collection	Annex 1 species	Notes
	(Australian National Mango Genebank)		Southedge (320 accessions, 17 species) Walkamin (320 accessions, 17 species)			2015. Minor international use. Mainly domestic breeding use
Queensland	Stanthorpe and Applehorpe Research stations	2007	Stone and pome fruits (363)	Field collection	Yes (*Malus*)	
Queensland	Maroochy Research Facility, Nambour	2007	Macadamia (72)	Field collection	no	
Queensland	BSES, Maringa,	2007	Sugarcane		no	
South Australia	Loxton Research Station	2012	Citrus (147) Walnut (35) Pecan (4) Avocado (17) Karob (9) Almonds (38) Grape vines (50 rootstock) Apricots (320) Peaches (35) Nectarines (10) European plum (15) Japanese plums (15) Damson Plum (1) Plumcot hybrids (2)	Field collection	Yes (Citrus)	Low distribution except for apricot
South Australia	Lenswood Research Centre	2012	Cherry (218)	Field collection	No	Distribution relatively high for research
Tasmania	DPI, Newtown	2007	Pome fruit (83)	Field collection	Yes (Malus)	
Victoria	Toolangi Research Station	2012	Potato (250)	Field collection	Yes	

Note: Information for this table was collected through consultation during 2012 or was drawn from information gathered during the 2007 review of the Plant Genetic Resource Centres.

Table 19 Accessions to the five major Australian plant genetic resource centres

Collection	2004	2005	2006	2007	2008	2009	2010	2011	2012
AWCC, Tamworth	1 043	492	450	272	85	463	2318	791	806
ATCFC, Biloela	569	447	543	276	59	227*	227*	313	444
AMGRC, Adelaide	3 076	4 656	2 579	3 439	1 797	–	–	–	–
ATFCC, Horsham	222	1 602	361	1121	185	190	464	118	463
ATGRC, Perth	711	369	187	410	139	–	–	–	–
Total	**5 621**	**7 566**	**4 120**	**5 518**	**2 111**	**653**	**2 782**	**1 222**	**1 713**

*Annual average over two years (2009 and 2010) when 455 accessions were added to the Biloela collection.

Note: The symbol – means no additions.

Table 20 Distributions from the five major Australian plant genetic resource centres

Collection	Destination	2004	2005	2006	2007	2008	2009	2010	2011	2012
AWCC,	Domestic	(13 295)	12 885	14 295	(9 911)	18 298	10 168	8 947	8 567	9 947
Tamworth	International		339	363		1 209	624	1 701	897	2 199
ATCFC,	Domestic	1 634	1 263	1 124	(1 969)	3 686	2 137	6 400	4 127	1 822
Horsham	International	574	808	383		876	220	1 291	930	0
AMGRC,	Domestic	3 122	4 188	2 379	(1 203)	1 142	769	942	602	825
Adelaide	International	435	2973	550		55	1324	16	14	2
ATFCC,	Domestic	(2 105)	894	794	(1 774)	1 383	2 223	3 158	2 844	1 968
Biloela	International		797	356		485	521	646	425	621
ATGRC,	Domestic	758	(442)	(943)	(250)	18	20	11	13	6
Perth	International	641				2	1	12	0	0

Note: Numbers in brackets represent total distributions from each PGRC.

Abbreviations and acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics (now ABARES)
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACIAR	Australian Centre for International Agricultural Research
ALA	*Atlas of Living Australia*
AMGRC	Australian Medicago Genetic Resource Centre (Adelaide, SA)
ARAS	Agricultural Research and Advisory Station
ASF	Australian Seed Federation
ATCFC	Australian Tropical Crops and Forages Collection (Biloela, Qld)
ATFCC	Australian Temperate Field Crops Collection (Horsham, Vic.)
ATGRC	Australian Trifolium Genetic Resource Centre (Perth, WA)
AusAid	Former Australian Agency for International Development
BRS	Bureau of Rural Sciences (now ABARES)
AWCC	Australian Winter Cereals Collection (Tamworth, NSW)
CAIGE	CIMMYT–Australia–ICARDA germplasm evaluation
CGIAR	Acronym only now used, formerly Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
DAFF	Department of Agriculture, Fisheries and Forestry – Australian Government
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GM	Genetically modified
GRDC	Grains Research and Development Corporation
GRIN	Global Resources Information Network
IARC	International Agricultural Research Centre (CGIAR)
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIS	International Crop Identification System
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture

NGIA	Nursery & Garden Industry Australia
NGO	Non-government organisation
NGRC	National Genetic Resource Centre
NVT	National Variety Trials
OECD	Organisation for Economic Co-operation and Development
PGR	Plant genetic resources
PGRC	Plant genetic resource centre
PGRFA	Plant genetic resources for food and agriculture
PICTs	Pacific Island Countries and Territories
R&D	Research and development
RDC	Research and development corporation
RD&E	Research, development and extension
SCoPI	Standing Council on Primary Industries
SMTA	Standard Material Transfer Agreement
WTO	World Trade Organization

References

ABARE–BRS 2010, *Statistical integration in designing Australian farm surveys*, Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences, Canberra, available at adl.brs.gov.au/data/warehouse/pe_abarebrs99001746/CP10.13_Design_Aust_Farm_surveys_PAPER.pdf

ABS 2010, *Year book Australia 2010*, Australian Bureau of Statistics, available from http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/AC72C92B23B6DF6DCA257737001B2BAB/$File/13010_2009_10.pdf

ABS, 2013, 7121.0 – *Agricultural commodities, Australia, 2011–12*, Australian Bureau of Statistics, available from http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02011-12?OpenDocument

ABS 2013, *Australia's population clock*, Australian Bureau of Statistics, available from http://www.abs.gov.au/ausstats/abs@.nsf/web+pages/population+clock?opendocument

ALA 2013, *Atlas of Living Australia*, available from http://www.ala.org.au/

ASF, 2013, ASF membership list, Australian Seed Federation, available from http://www.asf.asn.au/asf_member.php

Auricht, G, Grimes, G, Hughes, S, Redden, R & Snowball, R 2009, 'Australian plant genetic resources activities between 2004 and 2008', 14th Australasian Plant Breeding Conference APBC and the 11th Congress of the Society for the Advancement of Breeding Research in Asia and Oceania, Cairns.

Australian Plant Census, 2013, available from https://www.anbg.gov.au/chah/apc/

Brennan, J & Bialowas, A 2001, *Changes in characteristics of NSW wheat varieties, 1965–1997*, NSW Agriculture.

Brennan, J, Martin, P & Mullen, J 2004, An Assessment of the Economic, Environmental and Social Impacts of NSW Agriculture's Wheat Breeding Program. NSW Agriculture.

Costello, G, Gregory, M and Donatiu, P, 2009, Southern Macadamia Species Recovery Plan Available from http://www.environment.gov.au/biodiversity/threatened/publications/recovery/pubs/southern-macadamia-species.pdf

Crase, B, Duguid, A, Pengart, RN, Jakamarra, P, Angal, L , 2010, 'Distribution and Conservation Status of the Giant Sweet Potato, a Rare Aboriginal Food Plant from Central Australia.' Northern Territory Naturalist, 22, pp. 17–30.

DAFF 2012, *Australia's agriculture, fisheries and forestry at a glance*, Department of Agriculture, Fisheries and Forestry, available from http://www.daff.gov.au/__data/assets/pdf_file/0003/2161173/at-a-glance-june2012.pdf

FAO 1998, *The state of the world's plant genetic resources for food and agriculture*, Food and Agriculture Organization of the United Nations, available from ftp://ftp.fao.org/docrep/fao/meeting/015/w7324e.pdf

GRDC 2011, 'Wheat breeding information sheet', Grains Research and Development Corporation, available from http://www.grdc.com.au/uploads/documents/GRDC-FS-WheatBreeding.pdf

Hammer, K, Gladis, T & Diederichsen, A 2003, 'In situ and on-farm management of plant genetic resources', *European Journal of Agronomy*, 19(4), pp. 509–17.

Henry, R, Rice, N, Waters, DE, Kasem, S & Ishikawa, R 2010, 'Australian *Oryza*: utility and conservation', *Rice*, 3(4), pp. 235–41.

Hunt, JR & Kirkegaard, JA 2011, 'Re-evaluating the contribution of summer fallow rain to wheat yield in southern Australia', *Crop and Pasture Science*, 62(11), pp. 915–29.

James, RA, Davenport, RJ & Munns, R 2006, 'Physiological characterization of two genes for Na+ exclusion in durum wheat, Nax1 and Nax2', *Plant Physiology*, 142(4), pp. 1537–47.

Kirkegaard, JA & Hunt, JR 2010, 'Increasing productivity by matching farming system management and genotype in water-limited environments', *Journal of Experimental Botany*, pp. 4129–43.

Miller, R, Rausher, M & Manos, P 1999, 'Phylogenetic systematics of *Ipomoea* (Convolvulaceae) based on its ITS and waxy sequences', *Systematic Biology*, 24(2), pp. 209–27.

Moore, G & Tymowski, W 2005, *Explanatory guide to the International Treaty on Plant Genetic Resources for Food and Agriculture*, International Union for Conservation of Nature, Gland, Switzerland and Cambridge, UK, available from https://portals.iucn.org/library/efiles/html/EPLP057-expguide-international-treaty/cover.html

Munns, R, James, RA, Xu, B, Athman, A & Conn, SJ 2012, 'Wheat grain yield on saline soils is improved by an ancestral Na+ transporter gene', *Nat Biotech*, 30(4), pp. 360–4.

Natural Resource Management Ministerial Council 2010, *Australia's Biodiversity Conservation Strategy 2010–2030*, available from http://www.environment.gov.au/biodiversity/strategy/index.html.

NGIA 2013, *Nursery trade register*, Nursery & Garden Industry Australia, available from http://traderegister.ngia.com.au/

Nonomura, K, Morishima, H, Miyabayashi, T, Yamaki, S & Eiguchi, M 2010, 'The wild *Oryza* collection in National BioResource Project (NBRP) of Japan: history, biodiversity and utility', *Breeding Science*, 60, pp. 502–8.

Nossal, K & Sheng, Y 2010, *Productivity growth: trends, drivers and opportunities for broadacre and dairy industries*, Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Canberra.

NVT 2013, National Variety Trials, available from http://www.nvtonline.com.au/home.htm

Pastures Australia 2013, Pasture Picker, available from http://www.pasturepicker.com.au/

Price, HJ, Dillon, SL, Hodnett, G, Rooney, WL & Ross, L 2005, 'Genome evolution in the Genus *Sorghum* (Poaceae)', *Annals of Botany*, 95(1), pp. 219–27.

Productivity Commission 2005, *Trends in Australian agriculture*, Canberra, available from http://www.pc.gov.au/__data/assets/pdf_file/0018/8361/agriculture.pdf.

Trethowan, R, Mahmood, T, Ali, Z & Oldach, K 2011, 'Genetic control of wheat adaptation to conservation agriculture', 5th World Congress on Conservation Agriculture, Brisbane.

Van der Maesen, LJG, 2003, '*Cajaninae* of Australia (Leguminosae: *Papilionoideae*)', *Australian Systematic Botany*, 16(2), pp. 219–27.

WTO 2011, *Trade policy review: Australia*, World Trade Organization, available from http://www.wto.org/english/tratop_e/tpr_e/tp344_e.htm