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Published

2020

Journal Title

Australian Intellectual Property Journal

Version

Version of Record (VoR)

Quantitative Assessment of Applications for Plant Breeder's Rights under the Plant Breeder's Rights Act 1994 (Cth) from 1994 to 2019

Charles Lawson and Andrew Cecil*

This article reports on applications lodged under the Plant Breeder's Rights Act 1994 (Cth) from 10 November 1994, when the legislation entered into force, until 24 September 2019. The analyses address applications, grants, terminations and expirations of Plant Breeder's Rights (PBRs) according to the country of origin, plant form (trees, vines and others), plant groupings (amenity grasses and turfs, cereals, field crops, forage crops, fruit crops, fungi, ornamentals and vegetable crops), native plants and PBR duration. The main findings are that 5,141 PBRs have been granted, with approximately 210 new PBRs each year, Australian individuals, companies and other entities hold most granted PBRs and very few PBRs reach their full term. A closer analysis of cereals to demonstrate the methodology, and particularly Triticum aestivum (bread wheat), shows the transition from the public to private sector breeding, many PBR owners and each owner holding on average 4.5 PBRs suggesting a vibrant and competitive breeding sector for bread wheats.

INTRODUCTION

Australia joined the *International Convention for the Protection of New Varieties of Plants* (UPOV Convention)[1] to benefit Australian plant breeding through international recognition of Australia's national plant variety protection system, to encourage further investment in plant breeding in Australia, to increase community access to varieties, and to facilitate the transfer of technology and know-how from overseas.[2] This was also consistent with Australia's international intellectual property obligations under the World Trade Organisation's *Agreement on Trade-Related Aspects of Intellectual Property Rights*[3] to implement intellectual property protection for plants through a patent, a sui generis regime or a combination of both.[4] Plant patents are available under the *Patents Act 1990* (Cth);[5] and the *Plant Breeder's Rights Act 1994* (Cth) (the *PBR Act*) establishes a scheme for plant breeder's rights (PBRs) that conforms with the 1991 revision of UPOV Convention.[6] Under the *PBR Act*, breeders make applications for PBRs[7]

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[1] (1961) 815 UNTS 89, as revised at Geneva on 10 November 1972, on 23 October 1978, and on 19 March 1991 (*UPOV Convention*).

[2] Department of Agriculture Fisheries and Forestry, *International Convention for the Protection of New Varieties of Plants of 2 December 1961, as Revised at Geneva on 10 November 1972, on 23 October 1978, and on 19 March 1991 – National Interest Analysis* (1999) <http://www.austlii.edu.au/au/other/dfat/nia/1999/33.html>.

[3] *Marrakesh Agreement Establishing the World Trade Organization* (1994) 1869 UNTS 299, 33 ILM 1197, Annex 1C (*Agreement on Trade-related Aspects of Intellectual Property Rights*) (*TRIPS*).

[4] *TRIPS*, n 3, Art 27(3)(b).

[5] See Charles Lawson, "Taxonomic Conceptions of Algae, Animals, Fungi and Plants in Granting Intellectual Property Privileges" (2010) 19 *Griffith Law Review* 472, 477–483.

[6] Commonwealth, *Parliamentary Debates*, Senate, 24 March 1994, 2306 (Senator John Faulkner); Commonwealth, *Parliamentary Debates*, House of Representatives, 24 August 1994, 157 (Minister for Administrative Services).

[7] *Plant Breeder's Rights Act 1994* (Cth) s 24.

in a plant variety.[8] Once granted,[9] the PBR is the exclusive rights for the PBR holder to produce or reproduce, condition, offer for sale, sell, import the material, export or stock the protected propagating materials,[10] essentially derived varieties,[11] certain dependent plant varieties,[12] some harvested materials[13] and products obtained from harvested material,[14] and license others to do these things.[15] The term of the PBR is up to 25 years for trees and vines and 20 years for all other plant varieties.[16] The specific policy justification for the *PBR Act* was, consistent with Australia joining the UPOV Convention, that:

> PBR legislation conforming to the 1991 UPOV Convention is expected to provide a greater stimulus … to innovation by encouraging increased investment in plant breeding and technology transfer … [and c]ontinued innovation is needed to maintain Australia's competitiveness in agricultural and horticultural industries and the stimulation of technology transfer is crucial to maintaining Australia's access to new plant varieties for all plant industries.[17]

The Registrar of Plant Breeders' Rights (the Registrar)[18] was asked and has made available an extract from the database of all the applications lodged under the *PBR Act* up to 24 September 2019. The purpose of this assessment was to start a deeper evidence based engagement with the important policy issues based around the actual PBR practices. This article reports an overview of the data provided by the Registrar and identifies important policy questions that arise from the data. The results reported here are mainly descriptive as the data only enables some speculation about the likely causes for the results and further research will be necessary to confirm the likely causes. To understand the data more broadly the next parts outline the application process under the *PBR Act*, and then provides an overview of the dealings with applications for PBRs by the Registrar. The data analyses address applications, grants, terminations and expirations according to, among other things, the country of origin, the plant form (trees, vines and others), various plant groupings (amenity grasses and turfs, cereals, field crops, forage crops, fruit crops, fungi, ornamentals and vegetable crops), native plants, the PBR duration, and then a closer examination of PBRs and cereals and particularly *Triticum aestivum* (bread wheat) to demonstrate the methodology of interrogating the data in more detail. The PBR data are set out in a series of tables and figures at the end of the article.

The article concludes that the *PBR Act* is encouraging further investment in plant breeding and increasing access to plant varieties and facilitating technology transfer (including new varieties) and know-how from overseas. Further research, however, is necessary to more certainly map the reach of PBRs across plant groupings and varieties other than bread wheats and the role of PBRs in the breeding of some of those plant varieties. More importantly, the data provides the basis for a deeper engagement with important policy issues, such as country of origin of PBR applicants and the kinds of contributions these owners are making with their PBRs and whether this includes introducing associated breeding technology and know-how into Australia, plant groupings and the dynamics of the specific industries within those groupings and their uses of PBRs, whether shorter PBR terms might be more efficient, the granting of PBRs over native varieties and questions about traditional knowledge and benefit sharing, and whether PBRs have actually improved the quality of new varieties available to the market. The

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[8] *Plant Breeder's Rights Act 1994* (Cth) s 3(1) ("plant variety").

[9] *Plant Breeder's Rights Act 1994* (Cth) s 44.

[10] *Plant Breeder's Rights Act 1994* (Cth) s 11.

[11] *Plant Breeder's Rights Act 1994* (Cth) s 12.

[12] *Plant Breeder's Rights Act 1994* (Cth) s 13.

[13] *Plant Breeder's Rights Act 1994* (Cth) s 14.

[14] *Plant Breeder's Rights Act 1994* (Cth) s 15.

[15] *Plant Breeder's Rights Act 1994* (Cth) s 11.

[16] *Plant Breeder's Rights Act 1994* (Cth) s 22.

[17] Commonwealth, *Parliamentary Debates*, Senate, 24 March 1994, 2306 (Senator John Faulkner); Commonwealth, *Parliamentary Debates*, House of Representatives, 24 August 1994, 157 (Minister for Administrative Services).

[18] *Plant Breeder's Rights Act 1994* (Cth) s 58.

research reported here sets out the first steps in this project and provides a model for how this might be undertaken.

APPLYING FOR A PBR

Under the *PBR Act* an application for a PBR may be made by the breeder of a plant variety.[19] Where bred jointly the application must be made with all the breeders or with the consent of the breeder not applying.[20] This right to apply may be assigned, transferred by operation of law, and so on, to another as property.[21] The application is made on a standard form setting out details about the applicant(s), the breeder(s), the plant variety including the parental varieties, the manner of breeding, location of breeding, and so on.[22] For the application the plant variety must include a name for the variety.[23] The date of application sets the priority date unless an earlier date can be established from a foreign application for that same variety.[24]

After the application has been lodged with the PBRs Office,[25] the Registrar must decide whether to accept or reject the application.[26] The Registrar must accept the application if it has an earlier priority date, complies with the formal requirements of the application form, and "the application establishes a *prima facie* case for treating the plant variety as distinct from other varieties".[27] If any of these are not satisfied the Registrar must reject the application.[28] These decisions may be reviewed by the Administrative Appeals Tribunal.[29] An application can be withdrawn at any time.[30] The decision to accept or reject an application is published by the Registrar as a public notice in the *Plant Varieties Journal*.[31] Where an application is accepted then the PBR may be provisionally enforced from that date.[32]

After an application has been accepted, the applicant must provide the Registrar with a detailed description of the plant variety.[33] This will include "particulars of the characteristics that distinguish the variety from other plant varieties [of the same species] the existence of which is a matter of common knowledge" and any results from test growing "to establish that the variety is distinct, uniform and stable".[34] The description is then published by the Registrar as a public notice in the *Plant Varieties Journal*.[35] Within six months of this publication any person can lodge an objection if their commercial interests would be affected by the grant of that PBR.[36] Any person is able to access information about the application, the

[19] *Plant Breeder's Rights Act 1994* (Cth) s 24.

[20] *Plant Breeder's Rights Act 1994* (Cth) s 24(3) and (4).

[21] *Plant Breeder's Rights Act 1994* (Cth) s 25.

[22] *Plant Breeder's Rights Act 1994* (Cth) s 26.

[23] *Plant Breeder's Rights Act 1994* (Cth) s 27.

[24] *Plant Breeder's Rights Act 1994* (Cth) ss 28 and 29.

[25] *Plant Breeder's Rights Act 1994* (Cth) s 58(2).

[26] *Plant Breeder's Rights Act 1994* (Cth) s 30(1).

[27] *Plant Breeder's Rights Act 1994* (Cth) s 30(2).

[28] *Plant Breeder's Rights Act 1994* (Cth) s 30(3).

[29] *Plant Breeder's Rights Act 1994* (Cth) s 77(1)(b)(v).

[30] *Plant Breeder's Rights Act 1994* (Cth) s 33.

[31] *Plant Breeder's Rights Act 1994* (Cth) s 30(4) and (5).

[32] *Plant Breeder's Rights Act 1994* (Cth) s 39(1).

[33] *Plant Breeder's Rights Act 1994* (Cth) s 34(1).

[34] *Plant Breeder's Rights Act 1994* (Cth) s 34(4).

[35] *Plant Breeder's Rights Act 1994* (Cth) s 30(4) and (5).

[36] *Plant Breeder's Rights Act 1994* (Cth) s 35(1). The grounds of objections can be one or more of the following: an incomplete application, such as naming the wrong breeder (s 26(2)); there is no such a variety as described (s 44(1)(b)(i)); the variety is not a registrable plant variety because the variety does not have a breeder; the variety is not distinct, the variety is not uniform, the variety is not stable or the variety has been previously exploited (commercialised) (s 44(1)(b)(ii)); this might require a test growing:

description and the objections except the names of the parental varieties.[37] After the six months from the publication of the description in the *Plant Varieties Journal* has passed without an objection, or after an objection has been made, considered and put aside by the Registrar,[38] the application is considered and granted if the relevant thresholds have been satisfied.[39] When satisfied the Registrar grants a PBR certificate,[40] enters details on the Register,[41] and gives public notice of the grant in the *Plant Varieties Journal*.[42] Where the Registrar is not satisfied the application must be refused.[43] These decisions may be reviewed by the Administrative Appeals Tribunal.[44]

Overview of PBR Act Application Metrics

The Registrar maintains an accessible database of applications made and assessed under the *PBR Act*.[45] We have been provided with an extract from that database of all the applications lodged under the *PBR Act*. We selected only the applications made from 10 November 1994, when the *PBR Act* entered into force,[46] until 24 September 2019 when the data was collected. Applications made under the *Plant Variety Rights Act 1987* (Cth) were excluded. The data collected by the Registrar addressed the following data fields: application number, variety name, owner name (identification number), owner country of origin, genus, species, current status (received, accepted, granted, withdrawn, refused, rejected, terminates and expired), whether the variety is of an Australian native species, date of regulatory moment (withdrawal, refusal, termination or expiry), plant grouping (amenity grasses and turfs, cereals, field crops, forage crops, fruit crops, fungi, ornamentals and vegetable crops) and whether a tree or vine.

Over this period 10 November 1994 to 24 September 2019 under the *PBR Act* there were 8,554 applications received, 8,251 were accepted and 5,141 were granted (Table 1). This means the acceptance rate was 96% (acceptances divided by applications as a per cent) and the grant rate was 60% (grants divided by applications as a per cent). During this period 1,667 applications were withdrawn, 10 refused and 54 rejected at various stages during the assessment process (see Table 1).[47] Across each year there was some variability in applications received, accepted and granted (Figure 1). Over the full years 1997–2018 (1995–1996 was excluded because of the transition to the *PBR Act*) the average numbers of applications received, accepted and granted each year was 350, 339 and 219 applications respectively (standard deviations 30.1, 44.4 and 54.2 respectively). In this context of applications under the *PBR Act* these terms mean:

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ss 37 and 38); the applicant is not entitled to make the application (s 44(1)(b)(iii)); the grant of that right is prohibited by the Act (s 44(1)(b)(iv)); the variety has been granted to another person (s 44(1)(b)(v)); the variety is not properly named (s 44(1)(b)(vi)); the propagating material of that variety has not been deposited for storage in a genetic resource centre (s 44(1)(b)(vii)); and, a satisfactory specimen plant of the variety has not been supplied to an herbarium (s 44(1)(b)(viii)).

[37] *Plant Breeder's Rights Act 1994* (Cth) s 36.

[38] See *Plant Breeder's Rights Act 1994* (Cth) s 44(4).

[39] *Plant Breeder's Rights Act 1994* (Cth) s 44. This will include naming the breeder (s 26(2)); there is such a variety as described (s 44(1)(b)(i)); the variety is a registrable plant variety because the variety has a breeder (s 44(1)(b)(ii)); the variety is distinct, uniform, and stable, and the variety has been exploited (s 44(1)(b)(ii); this might require a test growing: ss 37 and 38); the applicant is entitled to make the application (s 44(1)(b)(iii)); the grant of that right is not prohibited by the Act (s 44(1)(b)(iv)); the variety has not been granted to another person (s 44(1)(b)(v)); the variety is properly named (s 44(1)(b)(vi)); the propagating material of that variety has been deposited for storage in a genetic resource centre (s 44(1)(b)(vii)); a satisfactory specimen plant of the variety has been supplied to an herbarium (s 44(1)(b)(viii)); the fees have been paid (s 44(1)(b)(ix)).

[40] *Plant Breeder's Rights Act 1994* (Cth) s 44(10).

[41] *Plant Breeder's Rights Act 1994* (Cth) s 46(1).

[42] *Plant Breeder's Rights Act 1994* (Cth) s 47(1).

[43] *Plant Breeder's Rights Act 1994* (Cth) s 44(3).

[44] *Plant Breeder's Rights Act 1994* (Cth) s 77(1)(b)(xv).

[45] See IP Australia, *Plant Breeder's Rights* <https://www.ipaustralia.gov.au/plant-breeders-rights>.

[46] *Plant Breeder's Rights Act 1994* (Cth) s 2(1); Australian Government, *Gazette 10 November 1994*, No S392, 1994.

[47] During this period 66 applications are recorded as received and appear to be under assessment at 24 September 2019.

- Received – The date an application by the breeder of a plant variety to the Registrar for the grant of a PBR in the variety[48] is filed with the PBRs Office at IP Australia either through the UPOV PRISMA portal[49] or the office's portal.[50]
- Accepted – The date the Registrar accepts the application that has an earlier priority date, complies with the formal requirements of the application form, and "the application establishes a *prima facie* case for treating the plant variety as distinct from other varieties".[51] The alternative decision in these circumstances is rejection.
- Granted – The date the Registrar accepts that the application meets the threshold requirements for the grant of the PBR.[52] The alternative decision in these circumstances is to refuse the application.
- Withdrawn – The date the applicant withdraws the application, and this can happen at any time.[53]
- Refused – The date the Registrar decides that on examination the application does not satisfy all the requirements for granting the PBR.[54] The alternative decision in these circumstances is to grant a PBR.
- Rejected – The date the Registrar decides not to accept the application because it does not satisfy the priority date, does not comply with the formal requirements of the application form, or "the application [does not] establish[] a *prima facie* case for treating the plant variety as distinct from other varieties".[55] The alternative decision in these circumstances is acceptance.
- Terminated – The date the Registrar decides the variety is either voluntarily surrendered[56] or revoked.[57]
- Expired – The maximum term of PBR has been reached and the exclusive rights of the PBR are not enforceable.[58]

TABLE 1. Applications under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of All Applications Received, Accepted, Granted, Withdrawn, Refused and Rejected

Applications	Numbers
Received	8,554
Accepted	8,251
Granted	5,141
Withdrawn	1,667
Refused	10
Rejected	54

[48] *Plant Breeder's Rights Act 1994* (Cth) s 24(1).

[49] See International Convention for the Protection of New Varieties of Plants, *UPOV PRISMA PBR Application Tool* <https://www.upov.int/upovprisma/en>.

[50] See IP Australia, n 45.

[51] *Plant Breeder's Rights Act 1994* (Cth) s 30(2).

[52] *Plant Breeder's Rights Act 1994* (Cth) s 44(1).

[53] *Plant Breeder's Rights Act 1994* (Cth) s 33(1).

[54] *Plant Breeder's Rights Act 1994* (Cth) s 44(1).

[55] *Plant Breeder's Rights Act 1994* (Cth) s 30(2).

[56] *Plant Breeder's Rights Act 1994* (Cth) s 52.

[57] *Plant Breeder's Rights Act 1994* (Cth) s 50.

[58] *Plant Breeder's Rights Act 1994* (Cth) s 22(2).

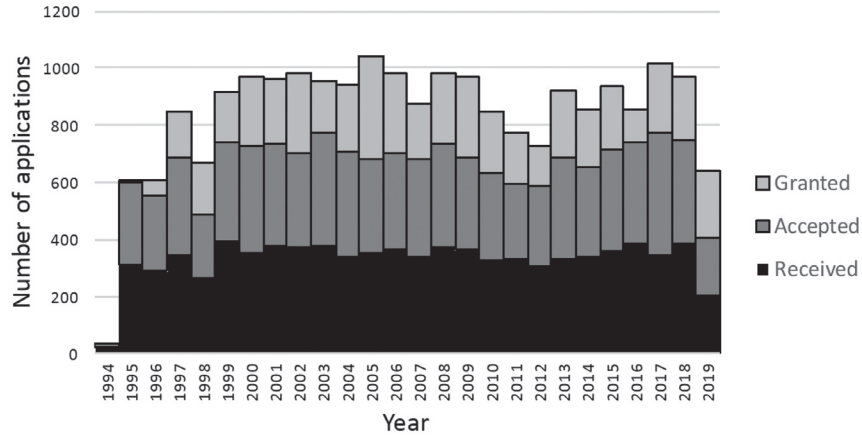

FIGURE 1. Received, accepted and granted PBR applications for full years from 1995 to 2018 under the *PBR Act*. Simple counting of applications received, accepted and granted by year.

The following parts address specific aspects of these applications: country of origin of applications; trees, vines, plant groupings and native plants; PBR duration; and the PBR landscape for cereals. The data are described and then there is some speculation about what this might mean, noting that determining the actual causes will require further research.

Country of Origin

The main countries of origin of the 8,554 applicants for PBRs were, in descending order of countries and the proportions of applications from those countries, Australia (3,987 applications, 47%), United States (1,426 applications, 17%), Netherlands (867 applications, 10%), New Zealand (442 applications, 5%), and so on (see Table 2). The main countries of origin of the 5,141 grants for PBRs were, in descending order, Australia (2,470 grants, 48%), United States (813 grants, 16%), Netherlands (531 grants, 10%), New Zealand (298 grants, 6%), and so on (see Table 2). The rate of conversion of applications to grants (so grants divided by applications as a per cent) was, in descending order, Australia (62%), United States (57%), Netherlands (61%), New Zealand (67%), and so on. These results show that Australian applicants lodged 2.8 times more applications than the next most prolific applicants from the United States, and that the success rates to grant were comparable (62% and 57% respectively).

TABLE 2. Top 15 Countries for Australian PBR Applications and Grants 10 November 1994 to 24 September 2019. Simple Counting of Applications Received and Grants Made for Each Country

Country	Applications	Grants
Australia	3,987	2,470
United States	1,426	813
Netherlands	867	531
New Zealand	442	298
Germany	419	284
United Kingdom	269	172
Japan	248	153
France	211	106

TABLE 2. *continued*

Denmark	153	70
South Africa	108	41
Italy	66	28
Israel	64	26
Spain	39	19
Canada	31	21
Belgium	24	16
Ireland	23	15
Switzerland	22	3
Chile	14	0
China	12	3
Austria	11	6

After the top three counties, Australia, United States and Netherlands, the applications and grants fall away highlighting the important relationship between these countries for plant breeding materials in Australia (Table 2). Considering these grants in more detail, and taking all grants made under the *PBR Act* (including those that have now terminated or expired) and according to plant groupings shows that the countries of origin are significant for different plant groupings (Table 3). Australia is the main origin of grants for amenity grasses and turfs (77%), cereals (87%), field crops (69%), forage crops (66%) and ornamentals (44%), while the United States is the main origin for fruit crops (54%), New Zealand for fungi (50%) and the Netherlands for vegetable crops (70%) (Table 3).

TABLE 3. Top 10 Countries According to All PBRs That Are or Have Been in Force in Australia for Each Plant Grouping between 10 November 1994 to 24 September 2019 – Number of Grants, Terminations and Expired PBRs (Proportion in the Plant Grouping). Simple Counting of All Granted, Terminated and Expired PBRs According to Each Plant Grouping with the Proportions (as a percentage within each plant grouping)

Country	Amenity Grasses and Turfs	Cereals	Field Crops	Forage Crops	Fruit Crops	Fungi	Ornamentals	Vegetable Crops
Australia	71(77%)	333(87%)	485(69%)	171(66%)	241(34%)	2(17%)	1,142(44%)	25(15%)
United States	20(22%)	15(4%)	51(7%)	8(3%)	382(54%)	1(8%)	326(13%)	9(5%)
Nether-lands	–	–	64(9%)	2(0.7%)	–	–	350(14%)	115(70%)
New Zea-land	1(1%)	14(4%)	22(3%)	75(3%)	56(8%)	6(50%)	122(5%)	–
Germany	–	–	30(4%)	–	10(1%)	–	246(10%)	–
United Kingdom	–	7(2%)	32(5%)	2(0.8%)	6(0.8%)	–	123(5%)	2(1%)
Japan	–	4(1%)	1(0.1%)	–	3(0.4%)	–	144(6%)	1(0.6%)
France	–	7(2%)	12(2%)	2(0.8%)	13(2%)	–	58(2%)	13(20%)
Denmark	–	1(0.2%)	3(0.4%)	–	–	3(25%)	61(2%)	–

The country of origin of applicants is important because the purposes of the *PBR Act*, implementing the UPOV Convention, were to increase community access to varieties and to facilitate the transfer of technology and know-how from overseas.[59] The data reveals that Australian owners are the most prolific users of the *PBR Act* and that all other users make up about half of all applications (Table 2). This suggests that foreign variety owners see advantage in making their varieties available to the public and for further breeding in Australia. The results do not, however, address the extent of the transfer of technology and know-how from overseas, and a closer analyses of the data shows that the different plant groupings have a different engagement with overseas owners (Table 3). Further research is necessary to determine the likely causes of the important relationship between some of these countries for plant breeding materials in Australia, and particularly fruit crops from the United States, fungi from New Zealand and vegetable crops from the Netherlands (Table 3). The high levels of Australian applications for amenity grasses and turfs, cereals, field crops and forage crops perhaps suggest a strong local breeding sector. A closer analysis of the parental contributions to these PBR'ed varieties is likely to show contributions from overseas germplasm and the kinds of technology and know-how transferred from overseas.

Trees, Vines, Plant Groupings and Native Plants

Of the 8,554 applications received between 10 November 1994 and 24 September 2019 when the data was collected, there were 5,141 granted PBRs (see Table 1). Reducing these high-level application counts to more detailed levels, such as the plant grouping including amenity grasses and turfs, cereals, field crops, forage crops, fruit crops, fungi, ornamentals and vegetable crops, reveals that the average acceptance rate was 97% (acceptances divided by applications as a per cent) and the average grant rate was 65% (grants divided by applications as a per cent) (Table 4). The highest conversion rate from accepted to granted was for cereals (77%) and followed by amenity grasses and turfs (75%) and fungi (75%). Of particular interest at this level of detail was the apparently low conversion rate of fruit crops and vegetable crops from applications received to grants of PBRs (48% for each) compared to the average (67%). The reason for this low conversion rate is not presently clear and raises interesting questions about the commercial practices of owners as the fruit crop and vegetable crop PBR owners are predominantly from the United States and the Netherlands (see Table 3).

TABLE 4 . Status of Applications for the Various Plant Groupings. Simple Counting of Applications Received, Accepted, Granted, Refused and Rejected for Each Plant Grouping with Measures of Conversion Calculated as a Ratio from Received to Accepted (Accepted Divided by Received), Received to Granted (Granted Divided by Received) and Accepted to Granted (Granted Divided by Accepted) Expressed as a percentage

Plant Grouping	Received	Accepted	Accepted/ Received	Granted	Granted/ Received	Granted/ Accepted	Refused	Rejected
Amenity grasses and turfs	133	133	100	100	75	75	–	–
Cereals	528	507	96	391	74	77	–	3
Field crops	1,070	1,022	96	745	70	73	4	–
Forage crops	374	365	98	264	71	72	1	–
Fruit crops	1,661	1,617	97	794	48	49	–	15
Fungi	17	16	94	12	71	75	–	–
Ornamentals	4,420	4,249	96	2,666	60	63	4	36
Vegetable crops	351	342	97	169	48	49	1	–
TOTALS (average)	**8,554**	**8,251**	**(97%)**	**5,141**	**(65%)**	**(67%)**	**10**	**54**

[59] Department of Agriculture Fisheries and Forestry, n 2.

The numbers of grants of particular plant groupings as a proportion of the total grants shows that, in decreasing order, the highest number of grants was ornamentals (52%), fruit crops (15%), field crops (14%), cereals (8%), forage crops (5%), vegetable crops (3%), amenity grasses and turfs (2%) and fungi (less than 1%) (Table 4). These results suggest that proportionally higher numbers of ornamentals are PBR'ed than other plant groupings. The causes are not presently clear, but might merely reflect the different kinds of markets for ornamentals compared to other varieties. For example, ornamentals may depend on continuous introductions of new varieties with novel colours and shapes to attract repeat consumers, necessitating lots of PBRs. Further research addressing the different marketing circumstances will be useful in uncovering the specific and different roles PBRs play in different marketing scenarios.

The *PBR Act* distinguishes between trees and vines and all other plant varieties in granting the term (duration) of exclusive rights.[60] The duration of a PBR for trees and vines is up to 25 years and up to 20 years for all other plant varieties.[61] The terms "trees" and "vines" are not defined in the *PBR Act* and the distinction appears to be made by the Registrar at the stage of acceptance, and often involves further investigation. In some instances, this classification is never finally determined (Table 5, footnote *). Where this determination has been made, the data showed 1,545 of the 8,554 applications were considered to be trees or vines (18%), 6,923 were not (81%) and 86 applications remained unclassified (Table 5).[62] Of these 1,545 tree and vine applications, there were 680 granted PBRs that comprised 510 fruit crops, 168 ornamentals and two field crops (*Paulownia fortune* and *Solanum tuberosum*) (Table 5).[63] Trees and vines were the majority of applications for fruit crops (73% of applications) while there appear to be some minor components in the classification of cereals (0.002% of applications), field crops (0.005% of applications), ornamentals (0.08% of applications) and vegetable crops (0.006% of applications) that appear to be misclassifications or errors (Table 5). For PBR grants 13% were trees or vines and again the majority of the 794 fruit crops were trees and vines (64%). And again, among the other varieties trees and vines were only very minor being recorded for field crops (0.003%) and ornamentals (6%) (Table 5). It is not clear why tree and vine varieties have a longer PBR duration than other varieties.[64] Perhaps surprisingly, there were no PBRs that continued past 20 years revealing that no tree and vine varieties took advantage of the longer PBR term (see also Table 7 and Figures 2 and 3).

[60] *Plant Breeder's Rights Act 1994* (Cth) s 22(2).

[61] *Plant Breeder's Rights Act 1994* (Cth) s 22(2).

[62] The reasons for 86 applications that remained unclassified is not clear. Of these applications, there were 30 applications received, two accepted, two rejected, eight terminated and 44 withdrawn, and these were comprised of four cereals, 24 field crops, one forage crop, four fruit crops, 50 field crops and three vegetable crops.

[63] These appear to be some very minor errors in the data. *Solanum tuberosum* is described in its taxonomic description as an herb: Carl Linnaeus, *Species Plantarum* (1753) Vol 1, 185.

[64] See Explanatory Memorandum, *Plant Breeder's Rights Bill 1994* (Cth) cl 22.

TABLE 5. Applications under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of Applications Received and Grants Made for Trees and Vines and Other Varieties According to Their Plant Grouping

Characteristic		Applications	Grants
Trees and vines	Cereals	1	0
	Field crops	5	2
	Fruit crops	1,204	510
	Ornamentals	332	168
	Vegetable crops	2	0
	TOTALS	**1,545***	**680**
Others	Amenity grasses and turfs	133	100
	Cereals	523	391
	Field crops	1,041	743
	Forage crops	373	264
	Fruit crops	452	284
	Fungi	17	12
	Ornamentals	4,038	2,498
	Vegetable crops	346	169
	TOTALS	**6,923***	**4,461**

* 86 applications had not been classified.

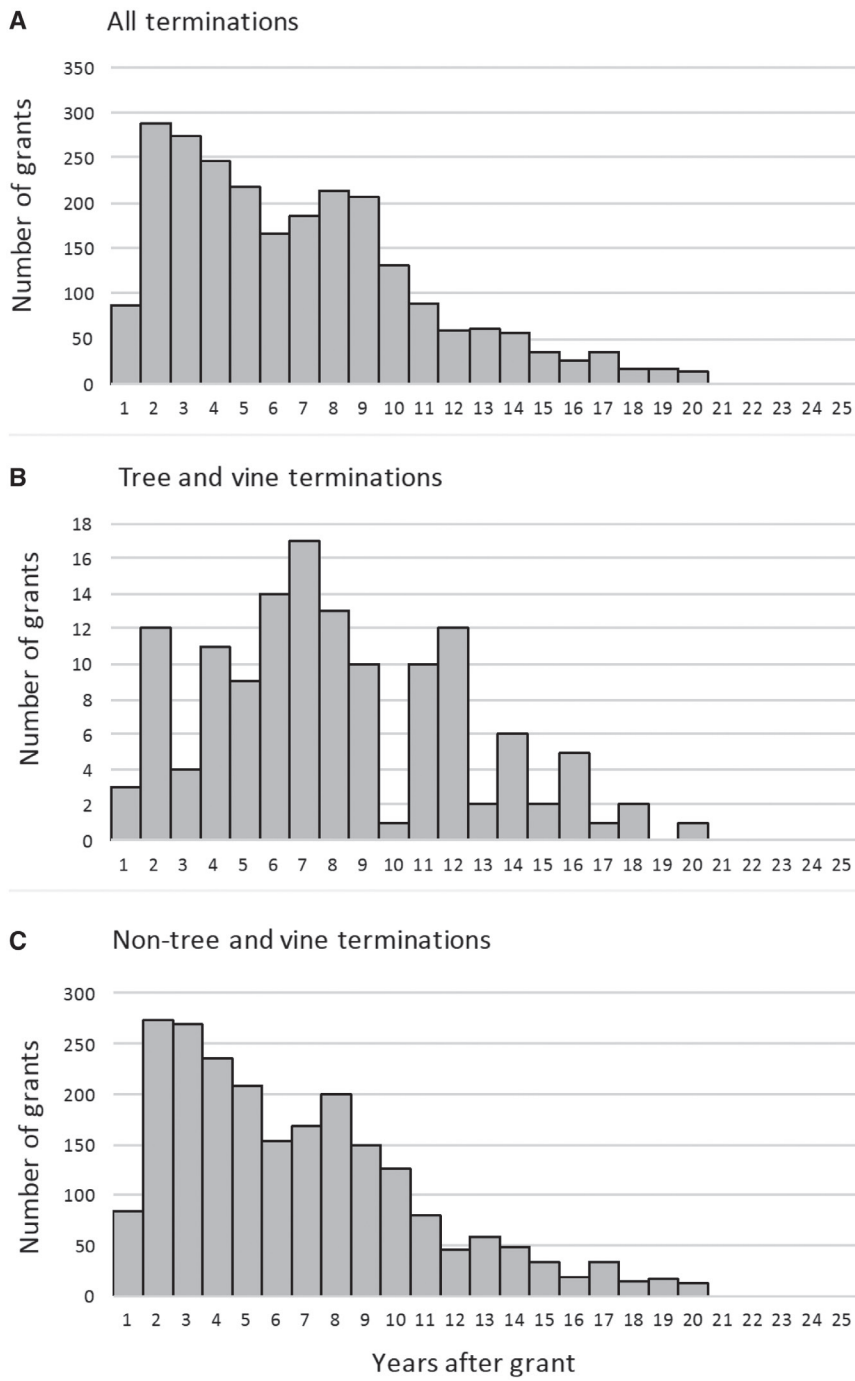

FIGURE 2. Terminations per year for granted PBRs after the PBR grant under the *PBR Act* for trees and vines and other varieties from 10 November 1994 to 24 September 2019. Simple counting of the number of years after grant that applications were terminated for all terminations (A), tree and vine terminations (B) and non-tree and vine terminations (C).

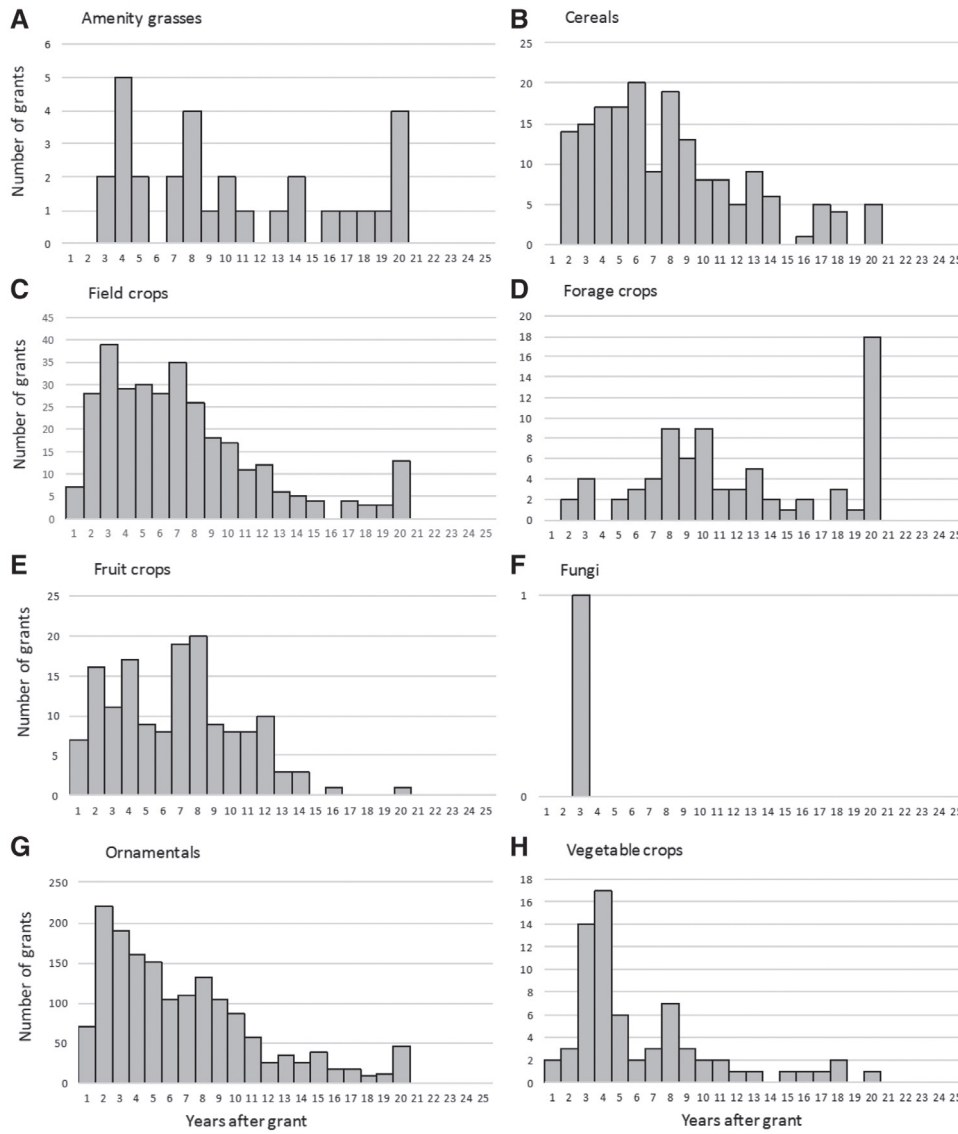

FIGURE 3. All terminations and expiries per year for granted PBRs under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple counting of the number of years after grant that applications expired or terminated for each plant grouping: amenity grasses and turfs (A), cereals (B), field crops (C), forage crops(D), fruit crops (E), fungi (F), ornamentals (G) and vegetable crops (H).

While the *PBR Act* grant does not distinguish between native plants and all other plant varieties, the Registrar does make this distinction because the *PBR Act* provides that the Registrar requires a satisfactory specimen of the variety be supplied to an herbarium.[65] The data showed 993 of the 8,554 applications were considered to be native plants (12%) (Table 6). Of these there were 117 tree and vine applications (12% native trees and vines) and 864 other plant variety applications (87% native non-trees

[65] *Plant Breeder's Rights Act 1994* (Cth) s 44(2).

and vines), and of these applications 542 were granted PBRs including 67 trees and vines and 474 other native plant varieties (Table 6).

TABLE 6. Native Plant Applications under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of Applications for Native (Indigenous) Plants Applications Received, Accepted, Granted, Refused and Rejected for Trees and Vines and Other Varieties.

Characteristic	Applications	Trees and Vines	Other
Received	993	117*	864*
Accepted	962	114	840
Granted	542	67	474
Withdrawn	271	29	235
Refused	1	0	1
Rejected	5	2	3

* 12 applications had not been classified.

PBR Duration

As explained above, the duration of a PBR is 25 years for trees and vines and 20 years for any other varieties.[66] The term starts on the date of the grant of PBR in the variety[67] and ends when the PBR expires at the end of the maximum term,[68] when the grant is terminated because the PBR holder surrenders the PBR[69] or when the PBR is revoked,[70] such as for the non-payment of annual renewal fees.[71] For the 5,141 PBR grants made, comprising 680 for trees and vines and 4,461 for other varieties (Table 5), the average durations of PBR was calculated in days (Table 7). There were 2,702 grants where the PBRs remain in force at 24 September 2019 and 2,439 grants that have either expired (74 grants) or been terminated (2,365 grants). For all 2,702 current PBRs that have not yet expired or been terminated (as at 24 September 2019), the average duration from the date of grant was 2,867 days or 7.8 years (with 90% of these durations being within 2,049 days of the 2,867 days (standard deviation)) (Table 7). Of the 2,439 grants that have been terminated or expired, the average duration from the date of grant was 2,402 days or 6.6 years (standard deviation 1,738 days). The average Australian owned PBR among the terminated and expired PBRs (1,071 grants) lasted 2,571 days or 7.0 years (standard deviation 1,852 days) while foreign owned terminated and expired PBRs (1,297 grants) lasted 2,254 days or 6.2 years (standard deviation 1,631 days).

[66] *Plant Breeder's Rights Act 1994* (Cth) s 22(2).

[67] *Plant Breeder's Rights Act 1994* (Cth) s 22(1).

[68] *Plant Breeder's Rights Act 1994* (Cth) s 22(2).

[69] *Plant Breeder's Rights Act 1994* (Cth) s 52.

[70] *Plant Breeder's Rights Act 1994* (Cth) s 50.

[71] *Plant Breeder's Rights Act 1994* (Cth) s 50(1)(b).

TABLE 7. PBR Duration of Grants That Have Expired or Been Terminated under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of Applications That Were Current, Expired or Terminated for All Applications, Plant Grouping Applications and Native (Indigenous) Plant Applications with the Duration of the PBR Determined in Days That Were Averaged with a Standard Deviation.

Applications That Have Been Granted			Number of Grants	Average PBR Duration (Days)		
				All Varieties	Trees and Vines	All Other (Non-tree and Non-vine) Varieties
All plants	All applications	Current valid grants	2,702	2,867(±2,049)	3,295(±2,140)[A]	2,759(±2,012)[A]
		Expired and terminated grants	2,439	2,402(±1,738)	2,801(±1,626)[A]	2,377(±1,741)[A]
		Expired grants	74	7,305	–	7,305
		Terminated grants	2,365	2,248(±1,528)	2,769(±1,585)[A]	2,215(±1,519)[A]
	Australian applications	Current valid grants	1,397	3,080(±2,081)	3,436(±2,323)	3,023(±2,032)
		Expired and terminated grants	1,071	2,571(±1,852)	3,003(±1,644)[B]	2,538(±1,862)[B]
		Expired grants	49	7,305	–	7,305
		Terminated grants	1,021	2,338(±1,562)	2,936(±1,551)[B]	2,292(±1,553)[B]
	Non-Australian applications	Current valid grants	1,305	2,638(±1,990)	3,210(±2,019)	2,420(±1,935)
		Expired and terminated grants	1,297	2,254(±1,631)	2,572(±1,603)[C]	2,254(±1,631)[C]
		Expired grants	24	7,305	–	7,305
		Terminated grants	1,336	2,179(±1,499)	2,572(±1,603)[C]	2,159(±1,491)[C]
Plant groupings (all countries)	Amenity grasses and turfs	Current valid grants	66	3,358(±1,849)	–	3,358(±1,849)
		Expired and terminated grants	34	3,616(±2,146)	–	3,616(±2,146)
		Expired grants	4	7,305	–	7,305
		Terminated grants	30	3,124(±1,779)	–	3,124(±1,779)
	Cereals	Current valid grants	216	2,292(±1,877)	–	2,291(±1,877)
		Expired and terminated grants	175	2,696(±1,660)	–	2,696(±1,660)
		Expired grants	5	7,305	–	7,305
		Terminated grants	170	2,561(±1,481)	–	2,561(±1,481)

TABLE 7. *continued*

	Field crops	Current valid grants	427	2,988(±2,120)	–	2,988(±2,120)
		Expired and terminated grants	318	2,467(±1,710)	2,328(±1,232)[D]	2,464(±1,711)[D]
		Expired grants	13	7,305	–	7,305
		Terminated grants	305	2,256(±1,415)	2,328(±1,231)[D]	2,250(±1,422)[D]
	Forage crops	Current valid grants	186	3,183(±2,181)	–	3,183(±2,181)
		Expired and terminated grants	78	4,125(±2,140)	–	4,125(±2,140)[E]
		Expired grants	15	7,305	–	7,305
		Terminated grants	62	3,381(±1,650)	–	3,381(±1,650)[E]
	Fruit crops	Current valid grants	642	2,837(±1,949)	3,253(±2,001)	2,037(±1,560)
		Expired and terminated grants	152	2,336(±1,420)	2,632(±1,345)[F]	1,928(±1,419)[F]
		Expired grants	1	7,305	–	7,305
		Terminated grants	151	2,303(±1,365)	2,607(±1,358)	1,842(±1,257)
	Fungi	Current valid grants	11	2,729(±1,926)	–	2,729(±1,926)
		Expired and terminated grants	1	1,445	–	1,445
		Expired grants	0	–	–	–
		Terminated grants	1	1,445	–	1,445
	Ornamentals	Current valid grants	1,053	2,850(±2,105)	3,446(±2,555)	2,772(±2,027)
		Expired and terminated grants	1,613	2,271(±1,694)	3,132(±2,013)[G]	2,246(±1,677)[G]
		Expired grants	35	7,305	7,305	7,305
		Terminated grants	1,578	2,159(±1,536)	3,043(±1,939)[G]	2,134(±1,514)[G]
	Vegetable crops	Current valid grants	101	1,573(±1,409)	–	1,573(±1,409)
		Expired and terminated grants	68	1,991(±1,498)	–	1,991(±1,498)[H]
		Expired grants	1	7,305	–	7,305
		Terminated grants	67	1,991(±1,360)	–	1,991(±1,360)[H]

Native plants	Native	Current valid grants	317	3,069(±2,164)	3,387(±2,584)	3,017(±2,082)
		Expired and terminated grants	224	2,439±(1,765)	3,080(±2,022)	2,356(±1,720)
		Expired grants	6	7,305	–	7,305
		Terminated grants	218	2,305(±1,592)	3,203(±1,981)	2,204(±1,509)
	Non-native	Current valid grants	2,385	2,840(±2,032)	2,722(±1,999)	3,288(±2,093)
		Expired and terminated grants	2,215	2,397(±1,733)	2,725(±1,538)[I]	2,380(±1,744)[I]
		Expired grants	68	7,305	7,305	7,305
		Terminated grants	2,139	2,243(±1,522)	2,665(±1,493)[I]	2,217(±1,520)[I]

[A] Eight applications had not been classified.
[B] Two applications had not been classified.
[C] Six applications had not been classified.
[D] Three applications had not been classified.
[E] One application had not been classified.
[F] One application had not been classified.
[G] Three applications had not been classified.
[H] One application had not been classified.
[I] Eight applications had not been classified.

When considered according to plant groupings the average grants were terminated or expired after 3,616 days or 9.9 years for amenity grasses and turfs, 2,696 days or 7.4 years for cereals, 2,467 days or 6.8 years for field crops, 4,125 days or 11.3 years for forage crops, 2,336 days or 6.4 years for fruit crops, 1,445 days or 4.0 years for fungi, 2,271 days or 7.6 years for ornamentals and 1,991 days or 5.5 years for vegetable crops (see also Figure 3).

The distribution of native and non-native plants showed that the majority of existing grants at 24 September 2019 were non-native (11.7% native and 88.3% non-native), and terminated and expired grants at 24 September 2019 were also majority non-native (9.2% native and 90.8% non-native).

The average duration for terminated and expired PBRs from the date of grant for native plant grants was 2,439 days or 6.7 years and for non-native plants was 2,397 days or 6.6 years (with standard deviations of 1,765 and 1,733 days respectively). Interestingly, for the 2,702 current PBRs that have not yet been terminated or expired as at 24 September 2019, the average duration from the date of grant was 3,069 days or 8.4 years for native and 2,840 days or 7.8 years for non-native plants (standard deviation 2,164 and 2,032 days respectively) that was longer than for the terminated and expired native and non-native PBRs.

A separate analysis of the duration of grants for trees and vines showed that, as indicated above, there were no PBRs that lasted for the full 25 years (Table 7 and Figures 2 and 3). Of the 2,439 grants that expired or were terminated before 24 September 2019, the average of grants for trees and vines was 2,801 days or 7.7 years (standard deviation 1,626 days) and for the non-trees and vines the average PBR lasted 2,377 days or 6.5 years from grant (standard deviation 1,741 days) (Table 7). The maximum tree and vine grants lasted 7,305 days or 20 years (Table 5 and Figures 2 and 3). As there were no tree and vines PBRs expiring at 25 years, comparing the number of grants that terminated per year after the grant shows peak terminations for all grants at two years (287 grants), tree and vine grants at seven years (17 grants) and non-tree and vine grants at two years (274 grants) (Figure 2). Visualising the terminations of all PBRs according to the number of years after grant (Figure 2) and the plant groupings according to the number of years after grant (Figure 3) showed that the majority of PBRs have terminated before 10 years (Figure 2A), the termination pattern for trees and vines appears to be fairly random (Figure

2B), and the largest number of non-tree and vine terminations are within the first three years of grant (Figure 2C). When this is considered according to the plant groupings, amenity grasses and fruit crops do not have a clear pattern (Figure 3A and 3E), while cereals, field crops, ornamentals and vegetables terminate soon after grants (approximately three years) (Figure 3B, 3C, 3G and 3H) and forage crops are notable for the proportion that reach 20 years' duration (Figure 3D).

The key insights from these results about PBR duration is that very, very few PBRs reach their maximum terms and no trees or vines take advantage of the additional five-year term over other varieties (Table 7 and Figures 2 and 3). The reasons why the overwhelming majority of PBRs terminate before they expire is uncertain, although different plant groupings have different termination and expiry profiles (see Figures 2 and 3).

CEREALS

We were particularly interested to investigate cereals further to test the potential of analysing the available data in more detail and as a model for how this data might be analysed. As a plant grouping, cereals made up 391 of the 5,141 granted PBRs from 10 November 1994 (date of entry into force) to 24 September 2019 (present) (Table 4). Of these grants 216 remain current, five have expired and 170 have been terminated (Table 7). The average duration for current grants was 2,291 days or 6.3 years (standard deviation 1,877), for terminated grants at 2,561 days or seven years (standard deviation 1,481 days), and there were no grants for tree or vine cereals (Tables 5 and 7).

Considering the data in more detail at the level of each of the cereal varieties *Avena sativa* (oats), *Hordeum vulgare* (barley), *Oryza sativa* (rice), *Secale cereal* (rye), *T. aestivum* (bread wheat), *Triticum turgidum* (durum wheat) and *xTriticosecale* (Triticale) showed that just over 50% of grants were for bread wheat with the next highest oats (18%) and barley (17%) (see Table 8). Like the broader granted PBR population few of these grants lasted to expiry at 20 years and the grants terminated on average at 2,667 days or 7.3 years for bread wheat (standard deviation 1,482 days), 2,649 days or 7.3 years for oats (standard deviation 1,447 days) and 2,420 days or 6.6 years for barley (standard deviation 1,584 days) (see Table 8). Only 1.8% of bread wheat, 5.1% of oats and 2.7% of barley reached the full term (Table 8). Among the cereal varieties Australia was overwhelmingly the country of origin of the grants across all the cereal varieties with the most diversity of origin being for oats, Triticale and bread wheat with four country origins each and barley with nine country origins (Table 9). The largest non-Australian country of origin was the United States for oats with 13 granted PBRs (Table 9).

TABLE 8. Cereal PBRs Granted, Expired or Terminated under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of Applications That Were Current, Expired or Terminated for Each Identified Cereal Grouping According to Name with the Duration of the PBR Determined in Days That Were Averaged with a Standard Deviation

Scientific Name	Common Name	Current Grant		Expired Grant		Terminated Grant	
		Number	Duration (Days)	Number	Duration (Days)	Number	Duration (Days)
Avena sativa	Oats	39	2,881(±2,258)	2	7,305	21	2,649(±1,447)
Hordeum vulgare	Barley	37	2,860(±1,556)	1	7,305	42	2,420(±1,584)
Oryza sativa	Rice	5	2,711(±1,829)	–	–	2	2,914(±1,434)
Secale cereale	Rye	2	2,131(±600)	–	–	one	2,507
Triticum aestivum	Bread wheat	111	3,175(±1,889)	2	7,305	85	2,667(±1,482)
Triticum turgidum	Durum wheat	12	2,458(±1,573)	–	–	4	2,735(±1,701)
xTriticosecale	Triticale	11	2,839(±1,159)	–	–	15	2,137(±1,046)

TABLE 9. Ownership of Granted Cereal PBRs (Granted, Terminated and Expired) under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of All Granted, Terminated and Expired PBRs for Each Country of Origin for Each Identified Cereal Grouping

	Number of Grants						
	Avena sativa	*Hordeum vulgare*	*Oryza sativa*	*Secale cereale*	*Triticum aestivum*	*Triticum turgidum*	*xTriticosecale*
Country of Origin	**Oats**	**Barley**	**Rice**	**Rye**	**Bread Wheat**	**Durum Wheat**	**Triticale**
Australia	42	59	6	3	189	14	20
Canada	4	1	–	–	–	–	–
Costa Rica	–	1	–	–	–	–	–
Denmark	–	1	–	–	–	–	–
France	–	3	–	–	4	–	–
Japan	–	4	–	–	–	–	–
Mexico	–	–	–	–	–	–	1
New Zealand	3	3	–	–	3	2	3
Singapore	–	–	1	–	–	–	–
South Africa	–	–	–	–	–	–	1
Spain	–	–	–	–	1	–	–
United Kingdom	–	7	–	–	–	–	–
United States	13	1	–	–	–	–	–

Interestingly, identifying distinct PBR owners according to the unique owner identity numbers provided with the Registrar's data showed that on average each owner holds less than three grants each with the largest holding of 18 grants for bread wheat, eight grants for oats and six grants for barley (Table 10). This also means that there are many different (unique identifier) owners of PBRs with 40 identified distinct PBR owners of bread wheat grants, 27 for oats and 24 for barley (Table 10). Examining this ownership more closely, however, revealed an artefact in the Registrar's data. Taking the unique identifiers provided with the data showed that, for example, for the identifier "1,747" the owner was "Australian Grain Technologies Pty Ltd", and that accounted for the largest holding of 18 current grants (Table 10). Instead of using the unique identifiers, however, using the names of the PBR owners showed that there were often multiple identifiers for each owner (Table 11). Based on this analysis the largest holding of bread wheat grants was "Australian Grain Technologies Pty Ltd" with 28 grants, followed by "LongReach Plant Breeders Management Pty Ltd" and "InterGrain Pty Ltd" with 20 and 16 grants respectively (Table 11). Based on this analysis the average holding was 4.5 grants per owner with 24 unique owners, although some owners were also part owners of other grants, particularly government departments, universities and governmental agencies (such as the Grains Research and Development Corporation) (Table 11).

TABLE 10. Ownership of Current Granted Cereal PBRs under the *PBR Act* from 10 November 1994 to 24 September 2019. Simple Counting of Current Applications for Each Identified Cereal Grouping According to Name of Owners Determined Based on the Registrar's Assigned Unique Owner Identification and Then Averaged with a Standard Deviation

Scientific Name	Common Name	Number of Grants	Number of Different Owners	Grants per Owner (Average)	Largest Holding of Grants
Avena sativa	Oats	39	27	1.4(±1.4)	8
Hordeum vulgare	Barley	37	24	1.5(±1.2)	6
Oryza sativa	Rice	5	4	1.3(±0.5)	2
Secale cereale	Rye	2	2	1	1
Triticum aestivum	Bread wheat	110	40	2.7(±3.6)	18
Triticum turgidum	Durum wheat	12	9	1.2(±0.4)	4
xTriticosecale	Triticale	11	7	1.6(±1.1)	4

TABLE 11. Current PBR Owners of *T. aestivum* (Bread Wheat) PBRs Based on Unique Identifiers and Title of Applicants Claiming PBRs. Simple Counting of Current Applications for Each Identified Cereal Grouping According to Listed Name of Owners (Not the Registrar's Assigned Unique Owner Identification) and Then Averaged with a Standard Deviation

Owner Identifications	Owner	Number of Grants
824, 1,527, 1,747, 2,666, 2,799, 2,988, 3,351	Australian Grain Technologies Pty Ltd	28
1,702, 2,045, 2,177, 2,536, 2,816	LongReach Plant Breeders Management Pty Ltd	20
1,764, 1,824, 2,216, 2,427	InterGrain Pty Ltd	16
287, 1,392, 1,705, 2,157, 2,164, 2,873, 3,156	University of Sydney and Grains Research and Development Corporation	8
1,203, 1,689, 3,114	Department of Agriculture and Fisheries Queensland, Department of Primary Industries New South Wales and Grains Research and Development Corporation	5
2,439, 1,934, 1,967	Allied Mills Pty Ltd and Arnott's Biscuits Ltd	4
721, 1,198, 2,548	Commonwealth Scientific and Industrial Research Organisation and Grains Research and Development Corporation	3
836	Department of Agriculture and Fisheries Queensland and Grains Research and Development Corporation	2
3,157	University of Sydney	2
3,317	Nuseed Pty Ltd	2
1,361	Council of Grain Grower Organisations Limited	2
1,757, 1,649	CC Benoist SAS	2
1,575, 2,989	Agriculture Victoria Services Pty Ltd and Grains Research and Development Corporation	2

TABLE 11. *continued*

729	Adelaide Research and Innovation Pty Ltd and Grains Research and Development Corporation	2
1,227	University of Adelaide	1
1,448	Department of Agriculture and Fisheries Queensland, Department of Primary Industries New South Wales, University of Queensland and Grains Research and Development Corporation	1
1,774	New Zealand Institute for Plant and Food Research Limited	1
3,158	Rebel Seeds Pty Ltd	1
2,793	Limagrain Europe sa	1
1,164	Department of Primary Industries New South Wales	1
1,642	Australian Grain Technologies Pty Ltd and University of Adelaide	1
3,083	Austgrains Pty Ltd	1
2,857	Agrigenetics, Inc.	1
876	Agriculture Victoria Services Pty Ltd and Grains Research and Development Corporation	1
	AVERAGE	**4.5(±6.9)**

A further analysis of the 261 bread wheat applications according to whether the applicants were made by the private sector, public sector (governments, government agencies and universities), or public/private sector collaborations showed a clear move from the public sector in the 1990s to the private sector in the 2000s (Figure 4). In this analysis the private sector applicants included corporations such as Australian Grain Technologies Pty Ltd, LongReach Plant Breeders Management Pty Ltd, InterGrain Pty Ltd, Agrigenetics, Inc, Limagrain Europe sa, and so on, while the public sector applicants included government departments (like the Western Australian Agriculture Authority, Queensland Department of Agriculture and Fisheries, New South Wales Department of Primary Industries, and so on), governmental agencies (like Commonwealth Scientific and Industrial Research Organisation, Grains Research and Development Corporation, Agriculture Victoria Services Pty Ltd, and so on) and universities (like University of Sydney, University of Adelaide, University of Queensland, and so on). The public/private collaborations were a small portion of applications in the 1990s and increased with the increasing predominance of the private sector applicants in the 2000s and then essentially stopped in the later 2000s (Figure 4). Then looking at the applicants in the last 10 years (from 2009 onwards), demonstrates the overwhelming engagement of the private sector and the very minor role of the public sector as PBR applicants, and the dominant place for bread wheat PBR applications (and breeding) of Australian Grain Technologies Pty Ltd (32 applications), LongReach Plant Breeders Management Pty Ltd (23 applications) and InterGrain Pty Ltd (19 applications) (Table 12).

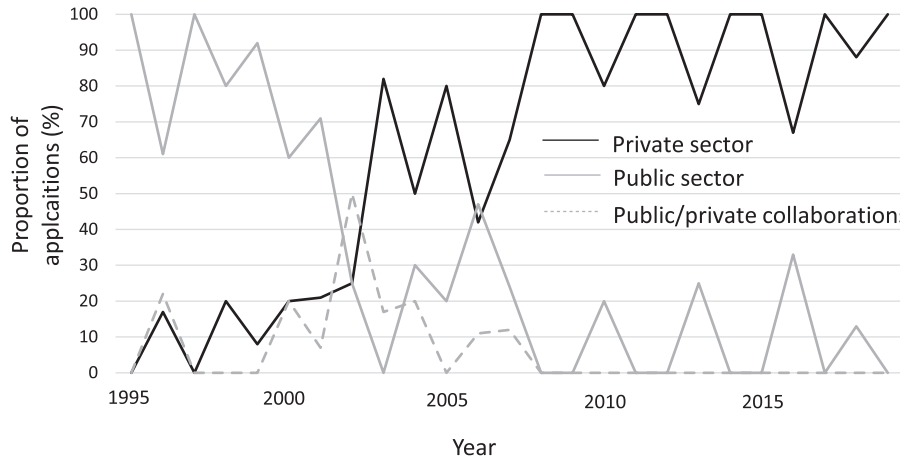

FIGURE 4. The proportions of PBR applications received for *T. aestivum* (bread wheat) according to sectors. Simple counting of the number of applications according to the owner being scored as private sector, public sector (governments, government agencies and universities), and public/private sector collaborations and then expressed as a proportion of applications received in that year.

TABLE 12. Applicants for PBRs for the Period 2009 to 2019 for *T. aestivum* – Private Sector or Public Sector. Simple Counting of Current Applications by Year for Each Listed Name of Owners (Not the Registrar's Assigned Unique Owner Identification) and Then Scored for Private Sector or Public Sector Status of the Owner

Year	Owner IDs	Owner Names	Private Sector	Public Sector	Number of Applications
2009	1,967	Allied Mills Australia Pty Ltd and Arnott's Biscuits Ltd	✓	✓	1
	2,045	LongReach Plant Breeders Management Pty Ltd	✓		2
	1,747	Australian Grain Technologies Pty Ltd	✓		1
	2,061	David Seth Cooper	✓		1
	1,764	InterGrain Pty Ltd	✓		2
2010	2,120	New Zealand Institute for Plant and Food Research Limited		✓	1
	2,177	LongReach Plant Breeders Management Pty Ltd	✓		1
	1,747	Australian Grain Technologies Pty Ltd	✓		4
	2,216	InterGrain Pty Ltd	✓		2
	3,157	University of Sydney		✓	1
	2,857	Agrigenetics, Inc.	✓		1
2011	2,177	LongReach Plant Breeders Management Pty Ltd	✓		4
	2,439	Allied Mills & Arnotts Biscuits Ltd	✓		1
	1,764	InterGrain Pty Ltd	✓		2
	1,747	Australian Grain Technologies Pty Ltd	✓		5

TABLE 12. *continued*

2012	1,747	Australian Grain Technologies Pty Ltd	✓		2
	2,177	LongReach Plant Breeders Management Pty Ltd	✓		2
	2,439	Allied Mills & Arnotts Biscuits Ltd	✓		1
2013	2,536	LongReach Plant Breeders Management Pty Ltd	✓		2
	2,548	CSIRO Plant Industry and Grains Research and Development Corporation		✓	1
	1,824	InterGrain Pty Ltd	✓		1
	2,628	George Weston Foods Ltd	✓		1
	2,634	Noel Francis Broun	✓		1
	1,747	Australian Grain Technologies Pty Ltd	✓		3
2014	2,536	LongReach Plant Breeders Management Pty Ltd	✓		1
	1,747, 2,666	Australian Grain Technologies Pty Ltd	✓		6
	1,764, 1,824	InterGrain Pty Ltd	✓		4
2015	1,824	InterGrain Pty Ltd	✓		1
	1,747, 2,666, 2,799	Australian Grain Technologies Pty Ltd	✓		4
	2,793	Limagrain Europe sa	✓		1
	2,816	LongReach Plant Breeders Management Pty Ltd	✓		1
	2,841	Agrigenetics, Inc	✓		2
2016	2,816	LongReach Plant Breeders Management Pty Ltd	✓		3
	1,764	InterGrain Pty Ltd	✓		2
	2,666	Australian Grain Technologies Pty Ltd	✓		1
	3,043	University of Queensland		✓	3
2017	3,081	Edstar Genetics Pty Ltd	✓		1
	3,083	Austgrains Pty Ltd	✓		1
	2,816	LongReach Plant Breeders Management Pty Ltd	✓		2
	2,666	Australian Grain Technologies Pty Ltd	✓		2
	3,158	Rebel Seeds Pty Ltd	✓		1
2018	3,216	Limagrain Europe sa	✓		3
	1,747, 2,666	Australian Grain Technologies Pty Ltd	✓		2
	1,764	InterGrain Pty Ltd	✓		4
	2,841	Agrigenetics, Inc	✓		2
	2,816	LongReach Plant Breeders Management Pty Ltd	✓		1
	3,269	University of Sydney		✓	2
	3,275	Edstar Genetics Pty Ltd	✓		1
2019	2,666, 3,351	Australian Grain Technologies Pty Ltd	✓		2
	1,764	InterGrain Pty Ltd	✓		1
	2,816	LongReach Plant Breeders Management Pty Ltd	✓		4

DISCUSSION

Australia joined the UPOV Convention to gain benefits including encouraging further investment in plant breeding in Australia, increasing community access to varieties and facilitating the transfer of technology (including new varieties) and know-how from overseas.[72] The *PBR Act* implemented the UPOV Convention standards in domestic laws in 1994 replacing the *Plant Variety Rights Act*.[73] In the subsequent (almost) 25 years to 24 September 2019, the key findings from this overview of the Registrar's dealing with PBRs shows that under the *PBR Act* there have been 5,141 PBRs granted (Table 1), Australian individuals, companies and other entities are the largest grouping of owners with 48% of all grants (Tables 1 and 2), and among the plant groupings PBRs are especially important for ornamentals, field crops and cereals (Table 4). Significantly, few PBRs reach their full term being terminated generally well before the expiry date (Figure 2). While there was some variation in the terms across plant groupings, the average PBR duration for already terminated and expired grants was 31% of their possible duration for trees and vines and 33% of their possible duration for all other varieties (Table 7). For the current valid grants (approximately 53% of all grants) these durations are all longer at 36% of their possible duration for trees and vines and 38% of their possible duration for all other varieties (Table 7). The same trend was apparent across all plant groupings except forage crops (Figure 3).

The results set out in Tables 1–7 and Figures 1–3 are primarily a description of the data made available by the Registrar. While this article essentially provides a description of this data set, these results raise intriguing questions that will now require further research to address. Some of these questions are:

- *Country of origin* – The data reveal important differences in the contributions of different countries to the different plant groupings (Tables 2 and 3). The questions that need to be addressed will include why the different plant groupings feature PBR owners from different countries (such as fruit crops from the United States and vegetable crops for the Netherlands), and the reasons these owners see merit in registering PBRs in Australia. It will also be important to gauge the kinds of contributions these owners are making with their PBRs and whether this includes introducing associated breeding technology and know-how into Australia, the kinds of engagement they are having with Australian entities and the kinds of benefits (PBRs and others) that are important to bring their protected varieties to Australia. There are clearly important relationships between different parts of the world for plant varieties, such as vegetable crops from the Netherlands, that will require close investigation to address Australia's needs for future food security and adaptation to climate change.
- *Plant groupings* – The plant groupings potentially identify different users with different interests in the *PBR Act*. For example, ornamentals are high users of PBRs with a large Australian PBR ownership and notable ownership across a number of other countries while vegetable crop PBRs are predominantly owned by Netherlands PBR holders (Table 3). Understanding more about the dynamics of these specific industries and their uses of PBRs will provide interesting insights into the *PBR Act* arrangements. The needs and wants of the different plant variety sectors, presently framed broadly as plant groupings, although this might not be the most appropriate framing and other classifications such as marketing arrangements, technology uses, species requirements, and so on, need to be explored.[74] Again, close investigation is necessary to address Australia's needs for future food security and adaptation to climate change.
- *Terms of protection* – Trees and vines and other varieties have different PBR durations, and the data clearly shows that most PBRs are terminated well before their PBR term expires. This raises intriguing questions about the efficiency and effectiveness of the current terms, whether shorter terms might be more efficient, and the likely effects of PBRs on unfairly restricting competition.

[72] Department of Agriculture Fisheries and Forestry, n 2. See also Productivity Commission, *Intellectual Property Arrangements*, Inquiry Report No 78 (2016) 409.

[73] Commonwealth, *Parliamentary Debates*, Senate, 24 March 1994; Commonwealth, *Parliamentary Debates*, House of Representatives, 24 August 1994. See also *Plant Breeder's Rights Act 1994* (Cth) s 78.

[74] Of particular interest will be the oats, triticale, durum wheat, apples, stone fruits, nuts, grape rootstock, lucerne and clover that are presently dependent on public sector and public/private partnership breeding programs: see Productivity Commission, n 72, 411.

And again there appear to be different durations for different plant groupings raising interesting questions about other dynamics interacting with the *PBR Act* arrangements – for example, why are forage crops the most likely to expire at the full PBR term?

- *Native varieties* – The Registrar collects information about the native varieties for the *PBR Act* purposes of confirming a specimen of the variety has been supplied to an herbarium (Tables 6 and 7). This data, however, raises intriguing questions about the status of these varieties and whether the evolving concerns about other policy issues, such as traditional knowledge and benefit sharing have some role. The developments under the *Convention on Biological Diversity* for a scheme of access and benefit sharing presents Australia with unique interests in native varieties (and information about those varieties) including the traditional knowledge associated with those varieties.[75]
- *Quality of varieties* – While the data show that PBRs have undoubtedly stimulated increased private sector investment and participation in plant breeding, there remains the question of whether this has actually improved the quality of new varieties available to the market. Further research is necessary to assess the measures of quality of new PBR'ed varieties (such as improved yields, farm productivity, better disease resistance, and so on) and the ongoing role of non-PBR'ed varieties still available and exploited in the market.

These are some of the questions raised by this overview of the data made available by the Registrar that require further investigation. Clearly this demonstrates that the data provides the basis for a lot more research and hopefully provides the first steps towards a much deeper engagement with the *PBR Act* and the community of breeders using the *PBR Act*.

The analysis of the plant grouping cereals, and particularly bread wheat, demonstrates the potential to mine the data for specific variety details (see Tables 8–12). The bread wheat data is particularly interesting because of the known shift in funding for plant breeding from the public to private sector breeding,[76] with similar shifts also apparent in Canada, the United Kingdom and France.[77] This was part of the broader governmental economic shift away from subsidies, tariffs, price guarantees, and included a shift in governmental interest and funding away from subsidising plant breeding to environmental, social and marketing issues.[78] The withdrawal of the government from plant breeding was to be replaced by the private sector as part of those micro-economic reforms.[79] The data, and specifically the number of applications over time held by the private sector, the public sector (governments, government agencies and universities), and in public/private sector collaborations over time (Figure 4), confirms this shift. Further research is, however, necessary to understand this apparent shift in breeders and breeding. Of particular interest will be an understanding of the kinds of public materials and know-how that shifted across from the public sector to the public/private sector collaborations and then to the private sector that was embodied in the shifting breeders and breeding.

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[75] See Charles Lawson, Fran Humphries and Michelle Rourke, "Legislative, Administrative and Policy Approaches to Access and Benefit Sharing (ABS) Genetic Resources: Digital Sequence Information (DSI) in New Zealand and Australian ABS Laws" (2019) 118 *Intellectual Property Forum* 40.

[76] See Emily Gray, Max Oss-Emer and Yu Sheng, *Australian Agricultural Productivity Growth: Past Reforms and Future Opportunities*, Research Report 14.2 (ABARES, 2014) 19; Julian Alston and Richard Gray, "Wheat Research Funding in Australia: The Rise of Public-private-producer Partnerships" (2013) 12 *EuroChoices* 30, 30; Charles Lawson, "The Evolution of a Workable Scheme for End Point Royalties for Plant Varieties" (2013) 94 *Intellectual Property Forum* 36, 40–45; Productivity Commission, *Rural Research and Development Corporations*, Report No 52 (2011) 11–20, 40; Ross Kingwell, "Institutional Change and Plant Variety Provision in Australia" (2005) 13 *Australasian Agribusiness Review* Paper 5 <http://www.agrifood.info/review/2005/Kingwell.html>. See also Bob Lindner, "Privatised Provision of Essential Plant Breeding Infrastructure" (2004) 48 *Australian Journal of Agricultural and Resource Economics* 301.

[77] Richard Grey et al, "Intellectual Property Rights and Canadian Wheat Breeding for the 21st Century" (2017) 65 *Canadian Journal of Agricultural Economics* 667.

[78] See David Briggs and Don Vernon, "Reassessing the Markets for Agricultural Services – Implications for Governments" (Paper presented at the 37th Annual Conference of the Australian Agricultural and Resource Economics Society, University of Sydney, 9–11 February 1993) <http://ageconsearch.umn.edu/record/147617/files/1993-03-18-19.pdf>.

[79] Productivity Commission, *Microeconomic Reform by Australian Governments 1997–98*, Annual Report Series 1997–1998 (AusInfo, 1998) 1–11.

In the early 2000s the Grains Research and Development Corporation established a series of companies dedicated to plant breeding – Australian Grain Technologies Pty Ltd established in 2002; HRZ Wheats Pty Ltd established in 2003; and InterGrain Pty Ltd established in 2007 – to encourage market based breeding programs.[80] Both Australian Grain Technologies Pty Ltd and InterGrain Pty Ltd are now major PBR applicants and PBR owners (Table 11). HRZ Wheats Pty Ltd was renamed Advantage Wheats Pty Ltd and acquired by Dow AgroSciences Australia Limited as a niche wheat breeder and then wound up in 2017.[81] The other major applicant, LongReach Plant Breeders Management Pty Ltd was established in 2002 as a joint venture between Syngenta Seeds Pty Ltd (now Syngenta Australia Pty Ltd) and AWB-Landmark, that now exists after a number of transactions as a partnership between Syngenta Australia Pty Ltd and Advanta Seeds Pty Ltd.[82] All these private companies were set up in the early 2000s and replaced the public sector breeding with private investment based around a model of PBR grants to establish and financially support their place in the bread wheat seed market. The analysis shows a vibrant breeding community with numbers of PBR applications, grants and breeders (Table 11) and ongoing new applications over the last 10 years (2009 to present) (Table 12). While this data indicates a healthy and competitive breeding community for bread wheat with multiple breeders (Tables 8–12), multiple varieties available to the market (as a PBR is premised on being publicly available)[83] and relatively short duration PBRs (Table 8), there remain concerns about the diversity of ownership and the potential concentration in other variety sectors.[84] Further research is necessary to identify some of these variety and plant grouping sectors to assess whether there are competitive breeding communities, and the possible need for other measures to stimulate investments and the release of new varieties.[85] This is now critical as the reduced support for the public sector breeding and outreach activities may now actually result in an underinvestment in some primary industry research and innovation and some plant breeding sectors.[86]

More broadly the Registrar's data identifies 3,386 unique owner identities, although the form of unique identifiers and multiple identities for some of the same PBR owners overestimates the number of unique owners (compare Tables 11 and 12). Australian individuals, companies and other entities do make the most applications and receive the most grants, although there are a significant number of applications and grants to a wide variety of other owner nationalities (Tables 2, 3 and 9). This suggests that the *PBR Act* is encouraging investment in plant breeding in Australia because Australian individuals, companies and other entities see value in taking up PBRs for their new varieties, and that there is a significant input into making plant varieties available in Australia from overseas because overseas breeders are applying and getting PBRs in Australia (that includes a requirement to make the variety available in Australia).[87] This is increasing community access to varieties because there are more new varieties available, and this is facilitating the transfer of technology and know-how from overseas in the form of new varieties available to the market and breeding in Australia (Table 2) (as well as the technology and know-how to carry on breeding programs in Australia). This is confirmed by the more detailed analysis of the bread

[80] See Richard Gray and Katarzyna Bolek, *Grain Research Funding in Australia: Lessons from International Experience* (2012) 11–14 <https://www.researchgate.net/publication/254385645>; Julian Alston, Richard Gray and Katarzyna Bolek, *Farmer-funded R&D: Institutional Innovations for Enhancing Agricultural Research Investments* (2012) 26–28 <http://www.ag-innovation.usask.ca/cairn_briefs/publications%20for%20download/CAIRN_2012_FarmerFundedRD_AlstonGrayBolek.pdf>.

[81] See Australian Securities and Investments Commission, *Advantage Wheats Pty Ltd CAN 106 590 434* (2017) <https://connectonline.asic.gov.au/RegistrySearch/faces/landing/panelSearch.jspx?searchText=106590434&searchType=OrgAndBusNm&_adf.ctrl-state=3jm11u8jv_15>.

[82] LongReach Plant Breeders Management Pty Ltd, *About LongReach* (2019) <https://www.longreachpb.com.au/about>.

[83] *Plant Breeder's Rights Act 1994* (Cth) s 19.

[84] See Australian Competition and Consumer Commission, *Statement of Issues: AGT – Proposed Acquisition of InterGrain* (2017) <https://www.accc.gov.au/system/files/public-registers/documents/MER17%2B3425.pdf>.

[85] See, eg, Charity Ruramai Nhemachena, Johann Kirsten and Binganidzo Muchara, "The Effects of Plant Breeders' Rights on Wheat Productivity and Varietal Improvement in South African Agriculture" (2019) 11 *Sustainability* 3378.

[86] Ross Kingwell, *The Rationale for Taxpayer Support for Primary Industry Research and Innovation in Western Australia* (Department of Agriculture and Food, 2018).

[87] See *Plant Breeder's Rights Act 1994* (Cth) s 19.

wheat PBRs that shows the substantial change from public sector to private sector PBR applications since the mid-2000s (Figure 4) and the very active engagement of the private sector in the last 10 years (since 2009) (Table 12). Perhaps most encouragingly, the PBR duration is a lot less than the possible full terms, meaning that new varieties are available to the market without any restrictions and that they are better varieties displacing existing varieties that are no longer considered sufficiently economically viable to justify protection through PBRs.

Together these findings suggest that the *PBR Act* justification of encouraging further investment in plant breeding in Australia and increasing community access to varieties is being delivered.[88] The remaining justifications of facilitating the transfer of technology and know-how from overseas can perhaps be presumed as the breeding sector brings from overseas both the technology and know-how and useful breeding materials to apply to their plant breeding – the active breeding programs for bread wheat by Australian Grain Technologies Pty Ltd, LongReach Plant Breeders Management Pty Ltd and InterGrain Pty Ltd and their multiple PBR applications (Tables 11 and 12) suggest a sophisticated approach using global technology and know-how and materials from overseas that are applied/bred in Australia. The same analysis needs to be extended to other plant groupings and varieties to determine whether this reduced support for the public sector breeding and outreach activities are an underinvestment affecting plant breeding in Australia, community access to varieties, and limiting the transfer of technology and know-how from overseas.

Conclusions

This study was only able to assess the broad metrics of PBR applications, grants, terminations and expirations, and has provided an indication that the *PBR Act* has and continues to address the needs of plant breeding in Australia. A further study of the quality of these applications is now required as well as some kind of assessment about the possible contribution of PBR grants to non-Australian individuals, companies and other entities to facilitate the transfer of technology and know-how from overseas. Further, this study has really only demonstrated the potential for analysis of specific varieties and their ownership to reveal interesting information about Australia's plant breeding. The analysis of bread wheat suggests a more detailed study linking the PBR data to other kinds of information (such as policy changes like the move from public to private sector breeding, end point royalties, and so on) should provide very useful insights into breeding niches that might benefit from more policy oversight. In addition, questions arise about those areas like bread wheat breeding that may no longer require the same kind of governmental investment that was available in the 1990s but might require a different kind of assistance or facilitation (such as enabling more efficient end point royalties). This study has, however, clearly demonstrated that the full dataset relating to the applications lodged under the *PBR Act* provides a useful and insightful view of PBRs in Australia and the potential for further research about PBRs.

[88] Department of Agriculture Fisheries and Forestry, n 2.