

Plants



Magnoliophyta (flowering plants)

Estimates for the number of described species of flowering plants in the world vary from 223,300 (Scotland and Wortley 2003) through 248,000 (Tangley 1997), 258,650 (Thorne 2002, IUCN 2004), about 270,000 (Groombridge and Jenkins 2002) to about 315,903 (Kier *et al.* 2009). The latter figure was calculated using range equivalents of vascular plants for all 90 regions of the world and representing 'a conservative estimate on the number of species of vascular plants known to science today' (Croft pers. comm.¹⁰⁶). The IUCN (2004) and Groombridge and Jenkins (2002) estimated that the total flora was about 320,000 species. IUCN (2009b) are now using the figures from Thorne (2002) citing the figure of 258,650. There have been 9,932 new species (excluding new combinations and *nom. nov.*) added to the *International Plant Names Index* (IPNI 2009) over the past five years (Nicolson pers. comm.¹⁰⁷). For this report, I have accepted the figure of 258,650 used in the previous report, plus the additional 9,932 species published since then. This gives a new figure of 268,600 when rounded to the nearest one hundred.

Govaerts (2002) estimated that there are 422,127 species of flowering plants based on the first volumes of his *World Checklist of Seed Plants*, whereas Bramwell (2002), using different methods, estimated a total of 421,968 species. In 2001, Prance (2001) estimated that there are between 300,000 and 320,000 species, whereas more recently Paton *et al.* (2008) have estimated that there are around 352,000

species in their work for Target 1 of the *Global Plant Strategy* (CBD 2009b). I have accepted the figure of 352,000 as the most likely, given the number of known published species and the rate of description over recent years, particularly in areas of Asia (e.g. New Guinea) and in tropical Central and South America. I believe figures in the low 300,000s are too low, and figures in the 400,000s too high.

Australian figures for flowering plants have varied from 15,638 (Walter and Gillett 1998, Williams 2001, Groombridge and Jenkins 2002) through 18,140 (DEH 2007) to 18,821 (Sjöström and Gross 2006). Sjöström and Gross (2006) reported a total of 18,821 species including 1,997 introduced species, thus giving a total of 16,824 native species. A count carried out as part of this report produced a figure of 18,448 native species on the Australian mainland and 18,706 when the offshore islands were included. Since the previous report, there have been many new taxa described, and a lot of work on developing and improving the *Australian Plant Census* (CHAH 2009a) and the *Australian Plant Name Index* (ANBG 2009). This has led to considerably higher numbers than those cited in the previous report. Confusion does arise with knowing whether some species are introduced or native, and whether some species I have regarded as endemic may not also occur in neighbouring Malesian regions including Papua New Guinea. I do, however, believe that the figures cited here of 18,448 and 18,706 ($\pm 1.0\%$) are realistic. The *Australian Plant Name Index* also lists around another 824

¹⁰⁶ pers. comm. Holger Croft, University of California, San Diego, April 2009.

¹⁰⁷ pers. comm. Nicola Nicolson, Royal Botanic Gardens, Kew, April 2009.

Magnoliophyta (flowering plants) *continued*

species as phrase or manuscript names¹⁰⁸—i.e. known but as yet unpublished species, and over 2,793 introduced and naturalised species. When all these are included, the total number of native species is 19,530 with 22,210 including native and naturalised species.

The estimates of 15,638, as cited by several authors, appear to have all been sourced from the Australian National Botanic Gardens (ANBG 2004) which referred to figures estimated in 1990. I expect that other estimates of around 22,000–25,000 include as many as 3,000 introduced species. The total number of native Australian flowering plants species would now appear to be somewhere between 20,000 and 21,000 or possibly slightly higher.

Estimates for endemism vary from about 85% (Williams 2001), 90% (Groombridge and Jenkins 2002) to 92% (Wong 1999). Groombridge and Jenkins (2002) cited a figure of 14,074 endemic species out of their total of 15,638, giving an endemism of 89%. In 1998, Conservation International provided a figure of 14,458 endemic species (Wong 1999).

In the previous report (Chapman 2006), I provided a figure of 91% endemism, with about 91.7% when the offshore islands were excluded. Since that report, many new species have been described, most being endemics. In addition many new species have been added as phrase names awaiting formal description. If we assume most of these are good species, calculated endemism in the Australian flora is 93.25% or 93.8% when offshore islands are excluded¹⁰⁹. These figures are based on counts carried out for this project using the *Australian Plant Census* (CHAH 2009a), *What's Its Name* (Australian National Herbarium *et al.* 2005), published hard-copy and online volumes of the *Flora of Australia* (ABRS 2009b), the *Australian Plant Name Index* (Chapman 1991), the electronic *Australian Plant Name Index* (ANBG 2009) and the *Census of Australian Vascular Plants* (Hnatiuk 1990). The total number of endemic species needs to be recalculated once the new *Australian Plant Census* of Australian vascular plant species is completed, and as most species still to be described are likely to be endemics, the percentage of endemism is expected to increase from these figures.



There are 1,202 listed threatened species of flowering plant in Australia, of which 52 are undescribed. There are also 104 listed infraspecific taxa of which four are undescribed (DEWHA 2009b). These lists include 37 species and two infraspecific taxa listed as Extinct; 72 species (six undescribed) and seven infraspecific taxa (one undescribed) listed as Critically Endangered; 475 species (34 undescribed) and 48 infraspecific taxa (one undescribed) listed as Endangered; and 618 species (12 undescribed) and 47 infraspecific taxa (two undescribed) listed as Vulnerable.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted ¹¹⁰	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹¹¹	Australia Threatened	Australian Threatened as percentage of World Threatened
223,300	315,903	~268,600	352,000	18,706	7.0%	~20,000–21,000	93.25%	7,904 (2.9%)	1,202 (6.4%)	15.2%

¹⁰⁸ Manuscript and phrase names are not included in the tables on numbers of species.

¹⁰⁹ NB These figures do not take into account introduced and naturalised species which would drop the figure down to about 82%.

¹¹⁰ Does not include 824 undescribed species that have been given either manuscript or phrase names.

¹¹¹ The IUCN Red List of Threatened Species (2009b).



Gymnosperms (Coniferophyta, Cycadophyta, Gnetophyta and Ginkgophyta)

There are a number of contrasting recent estimates for the number of described species of Gymnosperms in the world. Groombridge and Jenkins (2002) gave a figure of 846 while Christopher Earle in *The Gymnosperm Database* (Earle 2009) listed 956 species, the IUCN (2009b) gives a total of 980 species based on Donaldson (2003), Farjon (2001) and Mabberley (1997) and Paton *et al.* (2008 and pers. comm.¹¹²) list 1,001 species.

Hill and Stevenson (2004) in their *World List of Cycads* listed 275 known species of Cycad. The *International Plant Names Index* (IPNI 2009) has added another eight species since 2004 making 283 species in total. The *World Checklist of Selected Plant Families* (RBG, Kew 2009) lists 65 species of *Ephedra* (compared with 35 given in Earle (2009)), 41 species of *Gnetum*, one species of *Welwitschia* and one *Ginkgo*. Paton (pers. comm.¹¹²) states that there are 630 species of Coniferales (rather than the 1,016 listed in Paton *et al.* (2008)). This gives a total of 1,021 species of Gymnosperm—the figure I have accepted here.

No estimates for the total number of Gymnosperms has been found, but it is unlikely to be much greater than 1,050.

Figures for the Australian Gymnosperms include: Coniferophyta 44 (39 of which are endemic) (Hill 1998a); and Cycadophyta 76 (all of which are endemic) (Hill 1998b, CHAH 2009a). No estimate of the total gymnosperm flora of Australia has been found, but it is unlikely to be much higher than the presently known figure.

There are 17 listed threatened species in Australia and one threatened subspecies. These include seven species and one subspecies listed as Endangered and ten species listed as Vulnerable (DEWHA 2009b).

World Desc./ Accepted min.	World Desc./ Accepted max.	World Desc./ Accepted	World Estimate	Australia Desc./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹¹³	Australia Threatened	Australian Threatened as percentage of World Threatened
846	1,021	1,021	~1,050	120	11.7%	~120	96%	323 (31.6%)	17 (14.2%)	5.3%

¹¹² pers. comm. Alan Paton, Royal Botanic Gardens, Kew, May 2009.

¹¹³ The IUCN Red List of Threatened Species (2009b).

Ferns and Allies

Ferns and fern allies here have been taken to include the true ferns (Filicinophyta/Polypodiopsida), the club mosses, spike mosses, quillworts (Lycophyta, Lycopodiophyta/Lycopodiopsida, Selaginellopsida, Isoetopsida), spike horsetails (Sphenophyta/Sphenopsida) and whisk ferns (Psilophyta/Psilopsida) as recognised by various authors. Estimates for the numbers of described taxa include 13,025 from Groombridge and Jenkins (2002), who report numbers of c. 1,000 Lycophyta, c. 12,000 Filicinophyta, 10 Psilophyta and 15 Sphenophyta. Other estimates include 12,838 in the *Checklist of Ferns and Fern Allies* (Hassler and Swale 2002)—the figure accepted by IUCN (2009b). Interestingly, they also estimate a total number of species as between 10,614 and 12,001 which is less than the described number of species they include in the Checklist. Previous estimates from Swale (2000) were for between 10,000 and 15,000 species. Bostock (pers. comm.¹¹⁴) suggests that there could be somewhere about 15,000 species worldwide, however there is considerable uncertainty associated with hybridisation. In the previous report I accepted the figures of Hassler and Swale

(2002) for known species, and an estimate of 15,000 based on the figures of Swale (2000) and Bostock (pers. comm.¹¹⁴). I am now inclined to believe that the 'Species in Checklist' of Hassler and Swale (2002) really refers to names, whereas their 'Species estimate' refers to accepted species. I have thus now accepted a figure of c. 12,000 which they cite on their CD-ROM (Hassler and Swale 2001).

Bostock (pers. comm.¹¹⁴) suggests that for Australia (including Tasmania) there are 454 species of ferns (excluding hybrids and intergrades but including nothospecies i.e. *Drynaria × dumicola*). This increases by 25 if Lord Howe Island is included, by a further nine additional species when Norfolk Island is included, by eight more for Christmas Island, and two more when Macquarie Island is covered. There have been two new species published since 1998. In addition there are about 36 naturalised species. It is estimated that about 33.8% are endemic. Bostock (pers. comm.¹¹⁴) suggests a figure of about 525 as the total fern flora for Australia.



There are 41 listed threatened species and one listed variety in Australia. Nine are listed as Extinct, two as Critically Endangered, 16 as Endangered and 14 species and one variety as Vulnerable (DEWHA 2009b).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹¹⁵	Australia Threatened	Australian Threatened as percentage of World Threatened
10,000	15,000	~12,000	~15,000	498	4.2%	~525	33.8%	139 (1.2%)	41 (8.2%)	29.5%

¹¹⁴ pers. comm. Peter Bostock, Queensland Herbarium, June 2009.

¹¹⁵ The IUCN Red List of Threatened Species (2009b).



Bryophyta (mosses, liverworts, hornworts)



Estimates for the Bryophyta are complicated somewhat by the definition of the group (i.e. Phylum or Division). In some cases the category is circumscribed to include only the mosses, in others to include the hornworts, and liverworts, etc; hence the discrepancy in some of the cited numbers. Here, I am using it in the broader sense to include the true mosses (Bryopsida), the hornworts (Anthocerotopsida) and the liverworts (Marchantiopsida).

Estimates of the number of described species vary from 13,370 (Paton *et al.* 2008) through 15,000 (Hallingbäck and Hodgetts 2000), 16,000 (IUCN 2009b) to 23,000 (Helzner 2002). The University of Auckland (2009) provides figures of c. 10,000 for mosses, 6,500–7,000 for liverworts and c. 100 for hornworts, giving an estimate of 16,600–17,100 in total. Groombridge and Jenkins (2002) also provided estimates of 6,000 for liverworts and 600 for hornworts. De Luna *et al.* (2003) as part of the *The Tree of Life* project also provided an estimate for mosses of 10,000 species. Crosby *et al.* (1999) gave a figure of 12,754 for the mosses but many of these are synonyms. Crosby (pers. comm.¹¹⁶) is currently working on a new edition of the *Checklist of Mosses* and suggests that the final number of accepted species of mosses will be close to 11,000. There is considerable

variation in reported numbers for the liverworts—ranging from 5,000 to 9,000. On the *Discover Life* website (Buck *et al.* 2009) it states that there are between 7,500 and 9,000 species with over 7,500 currently listed. After a thorough count of the number of species in each genus, Stotler and Crandall-Stotler (2009) have now arrived at a figure of c. 5,000 (Stotler pers. comm.¹¹⁷). I have accepted c. 11,000 for mosses (Crandall-Stotler 2008), c. 5,000 for liverworts (Stotler & Crandall-Stotler 2009) and 236 for hornworts (Konrat *et al.* 2009 and Söderström and Hagborg pers. comm.¹¹⁸), totalling c. 16,236 species.

I have not found a published estimate for the total number of species for bryophytes, however Groombridge and Jenkins (2002) suggested that the proportion of the groups known is moderate to high for the mosses and moderate for both the hornworts and liverworts. Crandall-Stotler (2008) states that there are up to 15,000 species of moss recognised. Wikipedia¹¹⁹ suggests that there may be as many as 10,000 liverworts, however given that the number of published species is much lower than previously thought, this number is more likely to be closer to the lower end of the *Discover Life* estimate of 7,500. This would make a total somewhere around 22,600 for the bryophytes. This agrees with

116 pers. comm. Marshall Crosby, North Carolina, May 2009.

117 pers. comm. Ray Stotler, University of Southern Illinois, June 2009. There are still some genera for which numbers are not known so this is an approximation.

118 pers. comm. Lars Söderström, Department of Biology, NTNU, Norway, and Anders Hagborg, Field Museum, Chicago, June 2009.

119 *Wikipedia* (2009): Marchantiophyta. <http://en.wikipedia.org/wiki/Marchantiophyta> [Accessed 16 May 2009].

Bryophyta (mosses, liverworts, hornworts) *continued*

comments from McCarthy (pers. comm.¹²⁰) and Cargill (pers. comm.¹²¹) who suggest that the number would be much lower than the figure of 25,000 used in the previous report.

In Australia there are 976 species of moss (Klazenga pers. comm.¹²²) and 871 accepted species of liverworts and hornworts (McCarthy 2003, 2006). Of the 976 species of moss in Australia, 923 occur on the Australian mainland,

with the remainder on offshore islands or in the Australian Antarctic Territory. There are an estimated 222 endemic species of moss (Klazenga pers. comm.¹²²) (22.7% endemism) and between 200 and 250 endemic species of liverworts and hornworts¹²³ (23–28% endemism). DEH (2007) estimated the number of Australian species described at around 1,950, with about 2,500 species in total, but this would appear to be a little high.

There are two threatened bryophyte species listed as Vulnerable for Australia (DEWHA 2009b).

I am accepting the numbers in the lower line of the table which are an amalgam of Paton *et al.*'s (2008) estimate for World Described/Accepted species and Helzener (2002) for Accepted Maximum and my numbers derived from numerous estimates.

	World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹²⁴	Australia Threatened	Australian Threatened as percentage of World Threatened
Liverworts	5,000	9,000	~5,000	~7,500	841	16.8%	–	–	–	–	–
Hornworts	100	600	236	~250	30	12.7%	–	~23–28%	–	–	–
Mosses	10,000	12,754	~11,000	~15,000	976	8.9%	–	22.7%	82	1	1.2%
ALL BRYOPHYTA	13,370	23,000	~16,236	~22,750	1,847	11.4%	~2,200	25%	82 (0.4%)	1 (0.05%)	1.2%

120 pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, May 2009.

121 pers. comm. Christine Cargill, Centre for Plant Biodiversity Research, Canberra, June 2009.

122 pers. comm. Niels Klazenga, Royal Botanic Gardens, Melbourne, May 2009.

123 pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, Sept. 2005.

124 The IUCN Red List of Threatened Species (2009b).



Plant Algae (including green algae, red algae, glaucophytes)

Following more recent treatments, and the arrangements in *AlgaeBase* (Guiry and Guiry 2009), I have treated the algae of the previous report as plant algae (the red algae, green algae and glaucophytes—included here) and chromistan ‘algae’ under Chromista. Some species are treated under Protocista. Both Chromista and Protocista are treated later in this report.

The number of plant algae for the world is largely taken from *AlgaeBase* (Guiry and Guiry 2009). The total for the world is 12,272 made up of five Glaucophyta, 6,097 Rhodophyta, 2,125 Charophyta, and 4,045 Chlorophyta. As of 2005 the *AlgaeBase* database (Guiry *et al.* 2005) had only completed about 70% of taxa (with Rhodophyta and Phaeophyta 95% complete; and Chlorophyta with 95% marine and 50% freshwater complete ‘being deficient in the area of small freshwater greens, including the desmids. For the Haptophyta, Euglenophyta, Chrysophyta, Prasinophyta and Cryptophyta and other small phyla/classes we reckon

about 80% complete’). Since 2005, the database has been considerably improved and updated and is now much closer to completion in these groups.

Estimates for total numbers are mostly non-existent, although Metting (1996) includes figures for Rhodophyta of from 5,500–20,000, 20,500 for Charophyta and in the order of 13,000–100,000 for Chlorophyta. When compared to more recent figures for published species, many of these numbers appear to be on the high side.

The numbers for Australia are derived from Entwisle and Huisman (1998) and Cowan (2006). I have reported the numbers by Class following the classification used by *AlgaeBase*. The total for Australia is between 3,236 and 3,545 made up of one Glaucophyta, 1,040–1,099 Charophyta, 654–904 Chlorophyta (Entwisle and Huisman 1998), and 1,541 Rhodophyta (Cowan 2006).



The percentage endemism within Australia is unknown.

There are two threatened species listed for Australia (DEWHA 2009b)—one listed as Extinct in the Wild and one as Endangered.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹²⁵	Australia Threatened	Australian Threatened as percentage of World Threatened
12,205	12,272	12,272	unknown	3,236–3,545	26–29%	~3,000	unknown	9 (0.07%)	2 (0.06%)	22%

125 The IUCN Red List of Threatened Species (2009b).

Plant Algae (including green algae, red algae, glaucophytes) *continued*

Phylum	Class	World (AlgaeBase ¹²⁶)	Australia (Entwisle & Huisman 1998) ¹²⁷
Charophyta	Charophyceae	294	30–89
	Klebsormidiophyceae	65	10
	Mesostigmatophyceae	8	–
	Zygnematophyceae	1,758	1,000
Chlorophyta ¹²⁸	Bryopsidophyceae	520	150
	Chlorophyceae	2,238	279–479
	Incertae sedis	3	–
	Nephroselmidophyceae	23	–
	Pedinophyceae	22	5
	Pleurastrorhynchophyceae	4	–
	Prasinophyceae	135	43
	Trebouxiophyceae	170	–
	Ulvophyceae	930	177–227
	Zygnemophyceae	0	–
Glaucophyta ¹²⁹	Glaucocystales	5	1
Rhodophyta ¹³⁰	Bangiophyceae	134	12–16
	Composopogonophyceae	63	–
	Florideophyceae	5,878	1,079–1,274
	Rhodellophyceae	4	–
	Stylonematophyceae	18	–

126 *AlgaeBase* (Guiry & Guiry 2009).

127 Many of these figures would appear to be estimates only and not accepted species.

128 Corliss (2000) gives ~3,800, and Groombridge and Jenkins (2002) give ~16,000—compared to the *AlgaeBase* figure here of 3,913.

129 Corliss (2000) gives 15.

130 Corliss (2000) gives 4,250, and Groombridge and Jenkins (2002) give ~4,000—compared to the *AlgaeBase* figure here of 6,072.

