Xanthorrhoea: A review of current knowledge with a focus on *X. johnsonii* and *X. latifolia*, two Queensland protected plants-in-trade.

X. johnsonii © Jeffrey Wright[224]

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Summary

Project background and aims

Originally this report was only to review knowledge of *Xanthorrhoea johnsonii* and *X. latifolia*. Both are protected plants-in-trade in Queensland with significant numbers taken from the wild for the nursery trade and significant tonnage of foliage harvested for the florist trade. The initial aim was to determine if harvesting is ecologically sustainable, this information to be used in updating the management plan for Queensland protected plants-in-trade, which is due to expire in 2005. With major knowledge gaps for the two *Xanthorrhoea*, especially *X. latifolia*, it became apparent that information required to establish ecological sustainability and sound management of harvest for these and other Queensland *Xanthorrhoea* would require an Australia-wide *Xanthorrhoea* review. Therefore this report was broadened to do just that. In addition to providing information relevant to the management of ecologically sustainable harvest, this report provides valuable information for *Xanthorrhoea* management on conservation reserves.

Xanthorrhoea johnsonii

Limited information was found on its biology and ecology. It has a broad range through eastern Queensland, can grow to 5m with annual trunk growth estimated at 0.88cm. Specimens 5m tall could be over 550 years old. Flowering intensity can be influenced by fire. A flower spike can produce over 9000 seeds, but larvae of the moth *Meyriccia latro* can be significant seed predators. A number of animals are associated with *X. johnsonii*, but further surveys are required to document all animal usage. The importance of this usage to both plant and animals is largely unknown, but the plant is an important food resource for the endangered mahogany glider.

Although adult plants show some tolerance to fire, frequent fire can cause significant deaths in other arborescent *Xanthorrhoea* species. Investigations are required to determine the full impact of fire and develop optimum fire regimes. Cattle will feed on the leaves and young flower spikes with stock poisoning reported. The fungus *Phytophthora cinnamomi* is known to kill xanthorrhoeas, but its impact on *X. johnsonii* is unknown. There is no detail on the impact of clearing on *X. johnsonii*. However, about one-third of the 112 Queensland regional ecosystems in which it has so far been recorded have either an ”endangered” or “of concern” status because of clearing. It is recorded on 68 conservation reserves and 60 State forests or timber reserves. Although *X. johnsonii* is protected from clearing in conservation reserves, the high level of salvage harvest suggests clearing is still a potential threat elsewhere. Despite a wide distribution and high densities on some sites, there is no quantitative information on current and past population sizes. This information is needed to assess the sustainability of whole-plant harvest. In Queensland’s 2003–4 plant harvest season, over 41,500 *X. johnsonii* were officially taken. Illegal harvest may also be occurring. The size and age of legally taken plants is unknown and there is no information on their survivorship, although anecdotal information for other xanthorrhoeas suggests survivorship may be low.

During Queensland’s 2003–4 plant harvest season an estimated 41.9 tonnes of *X. johnsonii* foliage was harvested. Up to 1/3 of green leaves can be taken at each harvest from individual plants, but there is virtually no Environmental Protection Agency monitoring of harvest amount and frequency from individual plants. The ecological sustainability of *X. johnsonii* foliage harvest is largely unknown, even though a major Queensland foliage harvester has set up harvest monitoring plots. Although no impact was detected on leaf biomass from annual harvest on these plots over a seven-year period, results need to be treated cautiously. There are concerns about sample sizes, independent verification of data precision and accuracy and the possibility of measurement bias. The average annual leaf take from harvested plants on the plots is only 23 percent compared to the allowed wild harvest of 33 percent. Not all variables measured are appropriate to assess harvest impact. There has been no assessment of the impact of leaf harvest on plant growth, stored nutrients, flowering, seed production and associated animals. Government harvest monitoring guidelines need upgrading.

Xanthorrhoea latifolia* subsp. *latifolia

Very little was found on its biology and ecology. The plant can grow to 2m and has a patchy distribution in eastern Queensland. There is no information on growth, development and longevity. The impact of the root rot fungus *P. cinnamomi* is unknown and there is no information on the plant’s toxicity to stock. There is also no direct information on the impact of clearing. However, 29 of the 54 Queensland regional ecosystems in which it occurs have either an “endangered” or “of concern” status because of clearing. It is recorded on 43 conservation reserves and 16 State forests. Although occurring in a significant number of conservation reserves, the high level of salvage harvest suggests clearing is still a potential threat elsewhere. Despite a wide distribution in eastern Queensland, there is

no information on current and past population sizes. This information is required to assess the sustainability of harvesting whole plants. Like *X. johnsonii* there is no information on survivorship of wild-harvested plants. In the Queensland 2003–4 plant harvest season nearly 10,000 salvage-harvested *X. latifolia* subsp. *latifolia* were officially taken. Illegal harvest of whole plants may also occur. The size and age of legally taken plants is unknown. There is no information on survivorship of wild-harvested plants, although anecdotal information for other *Xanthorrhoea* suggests survivorship may be low.

During the Queensland 2003–4 harvest season an estimated 131.4 tonnes of *X. latifolia* subsp. *latifolia* foliage was harvested. There is virtually no EPA monitoring of harvest amount and frequency from individual plants. The ecological sustainability of harvesting is largely unknown. In 2003 a major Queensland foliage harvester set up two harvest monitoring plots for this species. Analysis of the limited data gathered so far shows no impact on leaf biomass on harvested plants, from annually harvesting 1/3 of the leaves. The precision and accuracy of data collected from these plots has not been independently verified, sample sizes are small and not all variables measured are considered appropriate to assess harvest impact. The impact of leaf harvest on plant growth, stored nutrients, flowering, seed production and associated animals needs assessment. Currently there are no records of the animals that use the plant or of the importance of that usage to plant and animal. A review of sample sizes, and how and which data are collected from the monitoring plots needs to be undertaken and Government monitoring guidelines require upgrading.

Xanthorrhoea

Xanthorrhoeas are endemic to Australia with 28 species and five subspecies currently recognised. The trunks in some species can grow to 6m. Although mean growth rate is only known for a few arborescent species and ranges from 0.88–2.6cm per year, individual plants can vary considerably in growth rate depending on environmental conditions. Cultivated from seed, faster growing *Xanthorrhoea* species can develop 10–15cm trunks in 10 to 15 years. In two *Xanthorrhoea* species leaves live 2–2.8 and 2–2.5 years respectively. Leaf growth in *X. preissii* appears to be continuous, ranging from 0.5–3.2 leaves per day. Inflorescence growth can reduce leaf growth. Growth of inflorescences can be rapid and up to around 10cm per day. Many *Xanthorrhoea* species grown from seed can first flower at 5–6 years of age. Flowering can still occur in *Xanthorrhoea* estimated to be 300 or more years old. Based on known growth rates, some tall *X. preissii* are estimated to be 350 years old, while radio carbon dating gave ages up to 600 years.

All *Xanthorrhoea* have a defined annual flowering period that can vary considerably between species. Flowering intensity can be influenced by factors like fire and foliage clipping. Some *Xanthorrhoea* species may produce more than 10,000 seeds on a flower spike. Seed dispersal appears limited. *Xanthorrhoea australis* seeds can remain viable after five years of appropriate storage. Temperature and light have been shown to influence seed germination. Once germinated, all *Xanthorrhoea* species develop contractile roots that initially draw the apical meristem down up to 12cm below ground. The little work on seedling survival in the field shows it can be poor.

Xanthorrhoeas are highly combustible and although arborescent plants can accumulate significant fuel they can survive fire. The impact of fire is influenced by fire frequency, timing and intensity. Leaf and inflorescence production can increase following fire. Although xanthorrhoeas have fire-protective mechanisms, significant fire deaths have been recorded in three arborescent species, including deaths of adult plants. The seeds of at least two species are not fire-tolerant. Over 315 invertebrates and nearly 100 vertebrates have been recorded using *Xanthorrhoea*. More animals can be expected to utilize *Xanthorrhoea* with little information on bats, rodents and spiders. There is scarce information on the importance of this utilization to both animal and plant. Some animal usage may be detrimental to xanthorrhoeas. For instance, regular browsing of *X. preissii* by Port Lincoln parrots can kill plants. Some *Xanthorrhoea* are toxic to stock, even causing death. Evidence suggests that feeding on young inflorescences is the cause of this poisoning, but further trials are required to identify all *Xanthorrhoea* species, plant parts and toxins responsible for stock poisoning.

There has been significant past indigenous and non-indigenous use of xanthorrhoeas. Whole plants, foliage, inflorescences, seeds, roots and trunks (wood turning) and resin are still harvested. The take of wild plants for the nursery trade is now prohibited or limited in a number of States, but is currently substantial in Queensland (e.g. nearly 60,000 plants in the 2003–4 harvest season), although non-salvage harvest quotas were reduced by 25 percent for the 2004–5 season. The level of illegal harvest is unknown in Australia, but is suspected to occur in a number of States.

The fungus *P. cinnamomi* is considered a serious threat to a number of *Xanthorrhoea* species outside Queensland. However, the little evidence available suggests its impact on *Xanthorrhoea* in Queensland may be minimal, but further research is required to confirm this. Other possible threats to *Xanthorrhoea* in Queensland and elsewhere include non-sustainable harvest (legal and illegal), clearing, grazing and inappropriate fire regimes. The only investigation of the impact of whole plant harvest was through population viability modelling of *X. resinifera* in New South Wales. For two simulated harvest scenarios where 21 percent of the adult *X. resinifera* present at the start of the simulations were harvested, average adult plant numbers were reduced by the end of the 100 simulation period by as much as 27 percent on numbers expected if no harvesting was to occur. Harvesting impact was least when harvesting was spread evenly over the 100-year simulation. Contrary to popular belief that *Xanthorrhoea* are fireproof, there is evidence that fire can cause significance deaths in arborescent *Xanthorrhoea*, although this has not been shown for Queensland species. What constitutes optimum fire regimes for Queensland *Xanthorrhoea* is still unclear. Fire-free periods ranging from three to 13 years have been suggested as appropriate to maintain *Xanthorrhoea* populations elsewhere in Australia, although under four years may seriously impact on seedling survival and adult plants may still be fire-affected as much as 25 years post-fire.

Minimum viable *Xanthorrhoea* populations may need to be around 500 breeding plants to maintain long-term genetic variability. This would equate to 2500 plants if 80 percent of a population consisted of immature plants. This does not take into account what a minimum population size should be to avoid extinction based on normal demographic and environmental stochasticity or the impact of catastrophic events such as severe drought or wildfire.

Management and research recommendations for Queensland *Xanthorrhoea*
If ecologically sustainable harvest of wild *Xanthorrhoea* is to continue in Queensland, this report makes 21 management and research recommendations. Summarized they are:

1. Identify all associated animals and determine the importance of this association.
2. Ban harvesting of *Xanthorrhoea* where the endangered mahogany glider occurs;
3. Harvesters to show the take of wild plants does not significantly affect associated animals, does not significantly deplete populations of any Queensland *Xanthorrhoea* taxa, and does not alter their population structures so reproductive output and recruitment are significantly reduced;
4. The Queensland EPA to at least annually adjust levels of non-salvage take of *Xanthorrhoea*;
5. Determine survivorship of Queensland *Xanthorrhoea* taken from the wild, and where necessary encourage development of better transplant and husbandry techniques to reduce death rates;
6. The Queensland EPA to review and where necessary update current *Xanthorrhoea* foliage harvest monitoring guidelines so meaningful conclusions can be derived on the impact of harvesting on *Xanthorrhoea* populations and associated animals;
7. The Queensland EPA to develop and regularly update and maintain a centralized database for *Xanthorrhoea* foliage harvested in Queensland; and
8. The Queensland EPA to at least annually set foliage harvest levels, set harvest periods and direct harvesters on where and how on State managed lands harvest will be allowed.

If harvesting of *Xanthorrhoea* whole plants or parts is to cease or is to be drastically reduced, especially as this review found no compelling scientific evidence that current harvesting is ecologically sustainable, then three recommendations are made. In summary they are:

1. Develop guidelines encouraging the establishment of nursery and plantation grown *Xanthorrhoea* to meet commercial demands;
2. Management guidelines for the ecologically sustainable harvest of *Xanthorrhoea* seed from the wild to meet nursery and plantation demands; and
3. A review of current *Xanthorrhoea* tagging and compliance systems to ensure commercially grown *Xanthorrhoea* can be readily identified and illegal wild harvest discouraged.

There is still little knowledge on possible threats to Queensland *Xanthorrhoea*, but if threats are real and prove difficult to ameliorate, then they may influence management of *Xanthorrhoea* harvest. Five management recommendations are made in relation to possible threats. In summary they are:

1. Determine optimum fire regimes for Queensland *Xanthorrhoea*;
2. Assess the impact of the fungus *P. cinnamomi* on Queensland *Xanthorrhoea*;
3. Determine impact of native and introduced herbivores on Queensland *Xanthorrhoea*;
4. Determine toxicity of Queensland *Xanthorrhoea* to stock and if required develop management options to minimize poisoning; and
5. Gather life-stage data to allow robust population viability modelling in relation to threats.

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Abbreviations

^{o}C	degrees centigrade
cal	calories
CALM	Western Australian Department of Conservation and Land Management
Ci	internal carbon dioxide concentration
cm	centimetre
CSIRO	Commonwealth Scientific and Industrial Research Organization
DPI&F	Queensland Department of Primary Industries and Fisheries
DPIWE	Tasmanian Department of Primary Industries, Water and Environment
EMP	expected minimum population
EPA	Queensland Environmental Protection Agency
EPBC	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
g	gram
ha	hectare
hr	hour
lbs	pounds
kg	kilogram
m	metre
mg	milligrams
mm	millimetre
n	sample size
NSW	New South Wales
p	probability
PVA	population viability analysis
Qld	Queensland
SA	South Australia
s.d.	standard deviation
sp.	species
spp.	more than one species
Tas	Tasmania
$\mu mol.m^{-2}s^{-1}$	micromols per metre^2 per second
Vic	Victoria
WA	Western Australia
>	greater than
≥	equal to or greater than
<	less than
≤	equal to or less than

1.0 Introduction

This report was initially commissioned to provide a literature review of the distribution, habitat preference, biology, ecology, associated species, usage, threats, population health, conservation and management of *Xanthorrhoea johnsonii* and *X. latifolia*. Both species are currently protected plants-in-trade in Queensland that are subject to wild harvest for either foliage, flowers, seeds or whole plants. Wild harvest is allowed under guidelines in the current State Government conservation and management plan for protected plants in Queensland. The management plan is due to expire in 2005 and a new plan is required. In undertaking this review, it became apparent that there was considerable additional information for *Xanthorrhoea* species Australia-wide that could have a bearing on any evaluation of current wild harvest of *Xanthorrhoea* in Queensland. This additional information is included in the report and is of a substantial but not always comprehensive nature. For instance, intensive searching of museum insect collections would probably yield further records of insect species utilizing *Xanthorrhoea*.

While this review report makes some conclusion relevant to *Xanthorrhoea* management and harvest in regards to ecological sustainability, it charter was not to make definitive statements as to whether *Xanthorrhoea* harvesting should continue in Queensland. Instead, the report should be seen as a major resource in the development of the new conservation and management plan for protected plants-in-trade, when the current plan expires in 2005.

Although this report is an information resource to help determine future management of *Xanthorrhoea* harvest, it is also a significant resource for Queensland Environmental Protection Agency (EPA) staff making decisions on *Xanthorrhoea* management in national parks and other conservation reserves within Queensland. The report provides an opportunity for EPA field staff to be aware of deficiencies in our knowledge of *Xanthorrhoea* and hopefully will encourage them to gather and pass on information to help fill these knowledge gaps. Even simple anecdotal information on the use of *Xanthorrhoea* by animals will help to build a better picture of the importance of this plant group within Queensland ecosystems.

To maintain the readability and flow of the text, this report does not adopt the Queensland Environmental Protection Agency's "house style" Harvard referencing system, instead using the numerical Vancouver system of referencing within the text. The Vancouver referencing system is outlined in the fifth edition of the *Australian Government Publishing Service Style Manual for Authors, Editors and Printers*.[366] References are listed in numeric order in section **6.0** of this report.

2.0 *Xanthorrhoea johnsonii* A.T. Lee

COMMON NAME: **forest grasstree**[6]

QUEENSLAND CONSERVATION STATUS: **Common, Type A Restricted**[1]

COMMONWEALTH CONSERVATION STATUS: **Not listed as threatened**[2]

2.1.0 Distribution

Xanthorrhoea johnsonii occurs from Singleton in New South Wales[7,17,143] to Cape York Peninsula, Queensland.[18] It is considered the most common and widespread species of *Xanthorrhoea* in Queensland and New South Wales.[90,143,227] See map below for Queensland distribution.

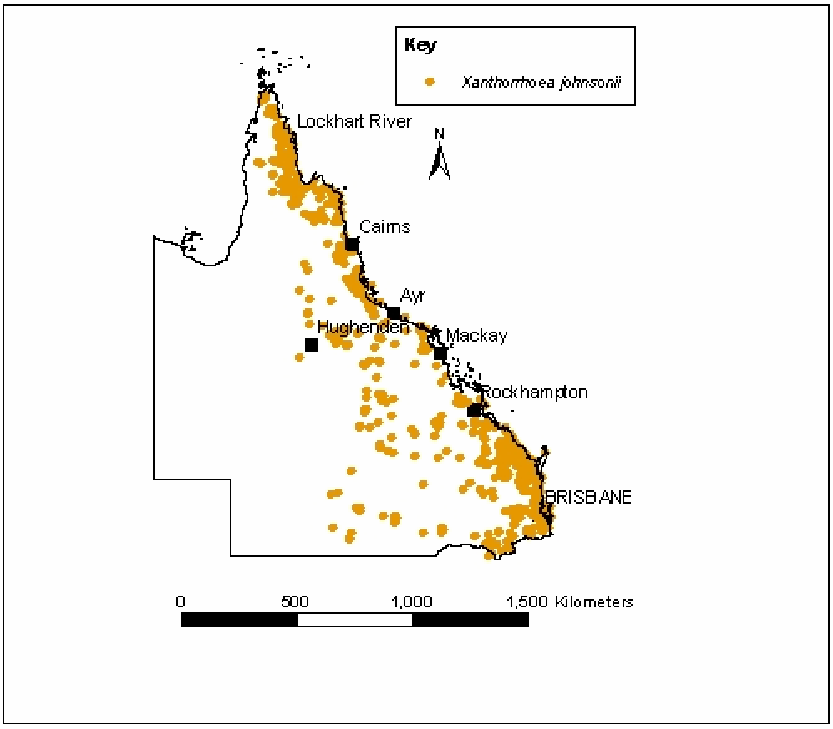


Figure 1: Queensland distribution of *Xanthorrhoea johnsonii*[16]

2.2.0 Description

A perennial[7] plant usually with an unbranched, arborescent stem (=trunk) mostly up to 2m tall, but occasionally up to 5m.[6] Also reported to only grow to ±4m.[100] The flower scapes (= flower stem or stalk) are 0.6–2m long and 0.7–2cm in diameter.[6] The flower spikes are 0.2–1.8m long occasionally over 2m, and 2–4cm in diameter.[6] The spikes are generally as long or slightly shorter than the scape, except in north Queensland where the spikes are quite commonly shorter.[112] Leaves are diamond-shaped (rhombic[6]) in cross-section and 1–2.5mm wide.[17] The 3-lobed fruits (capsules) are embedded in the flower spike,[17] and may contain more than one seed (mean 1.86 seeds).[90] The seeds are dull black in colour.[17] The mean number of green leaves on plants in Toohey Forest south-east Queensland that were not recently burnt was 1671 (s.d. 341; n=10).[10] The maximum number of green leaves on a plant not subjected to fire was 2140.[10] Mean number of green leaves on unharvested *X. johnsonii* on harvest monitoring plots in south-east Queensland was 668 (s.d. 284; range 148–1680; n=167).[334] Mean leaf weight for unharvested plants on these same plots was 2.56g (s.d. 0.58; range 1.48–4.1; n=40).[334] The number of leaf scars per cm^2 of trunk is 7–33.[10] There is a correlation ($P<0.01$) between the $\log_{10}$ number of scars per cm^2 and the circumference of the stem at the counting position.[10]

2.3.0 Similar species

This species is extremely variable, may include more than one taxon and requires further taxonomic work.[7,143] Superficially similar to *Xanthorrhoea latifolia*.[17] However, *X. latifolia* has larger leaves that are nearly flat, diamond-shaped to triangular in cross-section and 2.5–6mm wide.[6,17] *Xanthorrhoea johnsonii* hybridises with *X. fulva* in coastal south-east Queensland, the hybrid sometimes resembling *X. resinifera*.[143,227]

2.4.0 Habitat

Xanthorrhoea johnsonii occurs in a range of habitats, but is usually in sclerophyll forest (including woodland[14,215]) or heath,[7,143] often on sandy or gravelly soils.[112, 113] Recorded from 10–900m altitude in Queensland.[150] In south-eastern Queensland it grows in a variety of soil types,[6] and within the Greater Brisbane Region it is reported to grow in "well-drained shallow and often coarse-textured sandy stony soils on hill ridges, or on leached, deep sands".[17] Also reported to be "very plentiful on red sandy clay".[100] In Toohey Forest, south-east Queensland, *X. johnsonii* generally does not grow on the wetter creek-bed slopes, but is confined to terrain with well-drained sandy loams.[90]

This *Xanthorrhoea* has been recorded from 112 Queensland regional ecosystems (Table 1),[14] but can be expected to occur in more. One hundred (89 percent) of these 112 regional ecosystems have eucalypts in or dominating the overstorey.[15] Of the regional ecosystems in which *X. johnsonii* has been recorded, three have an "endangered" and 34 have an "of concern" vegetation management status, while four have an "endangered" and 36 have an "of concern" biodiversity status.[15] This means about one-third of the regional ecosystems that *X. johnsonii* has been recorded in are either of concern or are endangered.

Table 1: Queensland regional ecosystems in which *X. johnsonii* has been recorded and the status[15] of these regional ecosystems in 2003.

Regional ecosystem	Vegetation management status	Biodiversity status
7.3.8A	Not of concern	**Endangered**
7.12.25	Not of concern	No concern at present
7.12.27B	**Of concern**	**Of concern**
7.12.31	Not of concern	No concern at present
8.5.4	Not of concern	No concern at present
8.12.6c	Not of concern	No concern at present
8.12.7c	Not of concern	No concern at present
8.12.12a	Not of concern	No concern at present
8.12.22a	Not of concern	No concern at present
9.11.2a	Not of concern	No concern at present
9.12.2	Not of concern	No concern at present
9.12.4a	Not of concern	No concern at present
9.12.5	Not of concern	No concern at present
9.12.22	Not of concern	No concern at present
10.3.11	Not of concern	No concern at present
10.5.1	Not of concern	No concern at present
10.5.8	Not of concern	No concern at present
10.5.10	Not of concern	No concern at present
10.7.3	Not of concern	No concern at present
10.7.7	Not of concern	No concern at present
10.7.10	Not of concern	No concern at present
10.10.4	Not of concern	No concern at present
11.3.25	Not of concern	**Of concern**
11.5.1	Not of concern	No concern at present
11.5.4	Not of concern	No concern at present
11.5.5	Not of concern	No concern at present
11.7.4	Not of concern	No concern at present
11.7.4.1	Not of concern	No concern at present
11.7.5	Not of concern	No concern at present
11.7.7	Not of concern	No concern at present
11.10.1	Not of concern	No concern at present
11.10.2	**Of concern**	**Of concern**
11.10.4	Not of concern	No concern at present
11.10.5	Not of concern	No concern at present
11.10.13	Not of concern	No concern at present
11.10.13b	Not of concern	Not of concern
11.11.1	Not of concern	No concern at present
11.11.2	Not of concern	No concern at present
11.11.3	Not of concern	No concern at present
11.11.4	Not of concern	No concern at present
11.11.6	Not of concern	No concern at present

11.11.7	Not of concern	**Of concern**
11.11.12	Not of concern	No concern at present
11.11.15	Not of concern	No concern at present
11.11.15caf	Not of concern	No concern at present
11.12.1	Not of concern	No concern at present
11.12.13	Not of concern	No concern at present
11.12.16A	**Of concern**	**Of concern**
11.12.20	**Of concern**	**Of concern**
12.2.5	**Of concern**	**Of concern**
12.2.6	Not of concern	No concern at present
12.2.7	**Of concern**	**Of concern**
12.2.8	Not of concern	No concern at present
12.2.9	Not of concern	No concern at present
12.2.10	Not of concern	No concern at present
12.2.11	Not of concern	No concern at present
12.2.12	Not of concern	No concern at present
12.2.13	**Of concern**	**Of concern**
12.3.3	**Endangered**	**Endangered**
12.3.4	Not of concern	No concern at present
12.3.5	**Of concern**	**Of concern**
12.3.6	Not of concern	No concern at present
12.3.11	**Of concern**	**Of concern**
12.3.12	**Of concern**	**Of concern**
12.3.13	**Of concern**	**Of concern**
12.3.14	**Of concern**	**Of concern**
12.3.15	**Of concern**	**Of concern**
12.5.1	Not of concern	No concern at present
12.5.3	**Endangered**	**Endangered**
12.5.4	Not of concern	No concern at present
12.5.5	**Of concern**	**Of concern**
12.5.7	Not of concern	No concern at present
12.5.8	**Of concern**	**Of concern**
12.5.10	Not of concern	No concern at present
12.5.11	**Endangered**	**Endangered**
12.7.2	**Of concern**	**Of concern**
12.8.20	**Of concern**	**Of concern**
12.9-10.1	**Of concern**	**Of concern**
12.9-10.2	Not of concern	No concern at present
12.9-10.3	**Of concern**	**Of concern**
12.9-10.4	Not of concern	No concern at present
12.9-10-5	Not of concern	No concern at present
12.9-10.9	**Of concern**	**Of concern**
12.9-10.13	**Of concern**	**Of concern**
12.9-10.14	Not of concern	No concern at present
12.9-10.17	Not of concern	No concern at present
12.9-10.18	Not of concern	No concern at present
12.9-10.19	Not of concern	No concern at present
12.9-10.20	**Of concern**	**Of concern**
12.9-10.21	Not of concern	No concern at present
12.9-10.23	**Of concern**	**Of concern**
12.11.3	Not of concern	No concern at present
12.11.5	Not of concern	No concern at present
12.11.6	Not of concern	No concern at present
12.11.15	**Of concern**	**Of concern**
12.11.17	Not of concern	No concern at present
12.11.19	**Of concern**	**Of concern**
12.11.22	Not of concern	No concern at present
12.12.2	Not of concern	No concern at present
12.12.3	**Of concern**	**Of concern**
12.12.4	Not of concern	No concern at present
12.12.5	Not of concern	No concern at present
12.12.7	Not of concern	No concern at present
12.12.9	**Of concern**	**Of concern**
12.12.11	Not of concern	No concern at present

12.12.12	**Of concern**	**Of concern**
12.12.13	Not of concern	No concern at present
12.12.20	**Of concern**	**Of concern**
12.12.21	**Of concern**	**Of concern**
12.12.23	Not of concern	No concern at present
12.12.24	**Of concern**	**Of concern**
12.12.25	**Of concern**	**Of concern**
13.11.3	**Of concern**	**Of concern**
13.11.6	Not of concern	No concern at present

2.5.0 Biology and ecology

There is a direct relationship between height and age in arborescent grasstrees.[11] In Toohey Forest south-east Queensland, height increase of *X. johnsonii* was estimated to be 0.88cm per year (s.d.= 0.17) based on leaf production and leaf scar counts on the trunk (caudex).[10] This gave age estimates of 266 years for a 2.34m tall plant and 335 years for a plant 2.95m tall.[10] If as reported the occasional specimen can be up to 5m tall,[6] the estimated age of such a plant would be 568 years based on the estimated growth rate of 0.88cm per year in Toohey Forest.[10]

In *X. johnsonii*, the maximum rate of carbon dioxide assimilation by photosynthesis was measured in a laboratory trial at 19.9 μmol.m^{-2}.sec^{-1}.[266] The assimilation rate of *X. australis* was 70 percent less at 13.5 μmol.m^{-2}.sec^{-1}.[266] The differences between the two species in maximum carbon dioxide assimilation rate and carboxylation efficiency (Figure 2) were thought to be because *X. johnsonii* occurs in warmer and potentially drier habitat.[266] The maximum rate of photosynthesis in *X. johnsonii* as expressed by carbon dioxide assimilation, falls at the high end of C3 type grasses, and is well above most woody evergreens.[266,267]

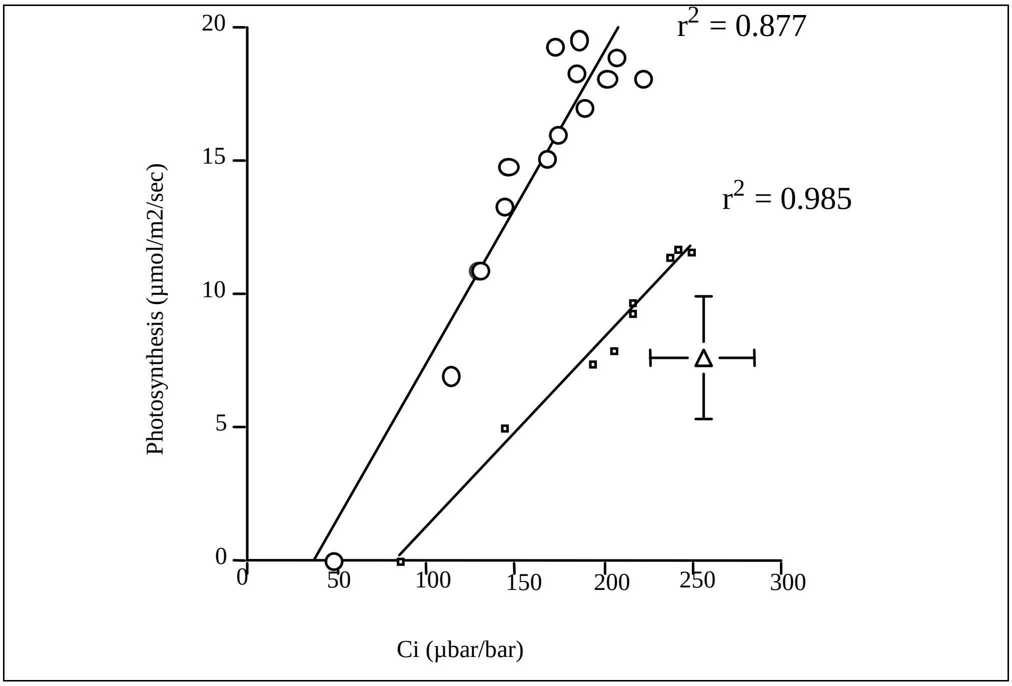


Figure 2: The linear response of carbon dioxide assimilation through photosynthesis to Ci (internal carbon dioxide concentration) in *Xanthorrhoea johnsonii* (o) and *X. australis* (□).[266] Regressions represent the carboxylation efficiency. Δ = *X. australis* field data collected *in situ* and shown with standard deviation.

The calculated average biomass of live leaves on unharvested *X. johnsonii* from harvest monitoring plots in south-east Queensland between 1997 and 2003 was 1710g (range 379–4301g; n = 167).[334] Leaf biomass calculations were based on a leaf weight of 2.56 grams.[334] Leaf growth is affected by fire (for details see sections **2.7.3** and **4.7.3.2** of this report).

Xanthorrhoea johnsonii flowers are bisexual,[7,143] with the male flower parts developing before the female parts (protandrous).[90,143] Although self-pollination is possible in *X. johnsonii*, it appears limited because insect pollinators are very efficient at removing pollen from a flower spike before its female parts mature.[90] Pollen dispersal is dependent on appropriate pollinators and their movement patterns.[90] *Xanthorrhoea johnsonii* flowers in New South Wales from April to December,[7] in south-east Queensland from April–December (autumn to summer[6]),[17] and in the Cardwell area of north Queensland from May to August.[8] In Toohey Forest south-east Queensland, flowering was recorded from mid-May to mid-October, with peak flowering around mid-August.[90] Each plant has a mean flowering period of about 38 days in Toohey Forest, but plants flowering early in the season had flowers open for longer than plants flowering late in the season.[90] Field observations from the same area suggest that plants near a vegetation edge or higher up on a slope began flowering before plants in shaded areas.[90]

In Toohey Forest, south-east Queensland, *X. johnsonii* generally do not commence flowering until the trunk is about 20 cm in height at about 23 years of age, with plants still flowering at 2.6m in height (ca 295 years of age).[90] In nursery conditions *X. johnsonii* can be grown from seed to flowering stage in about 5–6 years.[261] Research carried out around 1980 found flowering potential in wild plants appears to increase up to about 50 years of age and is then relatively stable.[10] More recent research found the tallest plants have the highest probability of flowering.[90] Mature plants on average flower about once every five years.[10] The time of flowering is independent of plant age.[90] Flowering can occur without fire,[356] but in the first flowering season following a fire there is an increase in the proportion of plants flowering.[10,90,356] Normally in the second flowering season following a fire, very few *X. johnsonii* plants will flower.[90] Although flowering in other *Xanthorrhoea* species increased in the first flowering season following a fire,[11,12,102,103,104,105,116,136,143,156,161] in some the flowering can peak in the second year post-fire.[155,323] (See section **4.7.3.2** of this report)

For *X. johnsonii* in Toohey Forest, seed maturation takes about three months and by the onset of summer most ripened seeds have been shed.[90] However, seed predation by the moth *Meyriccia (Hylaletis) latro* can be significant, and entire seed sets can be lost on some plants.[90] There is evidence to suggest the moth lays its eggs on the spikes when they are immature.[90] Plants flowering early in the season sustain less damage from the moth larvae.[90] Minor seed predators at the same location include possums and very occasionally parrots (pale-headed rosella *Platycercus adscitus* and scaly-breasted lorikeet *Trichoglossus chlorolepidotus*[158]).[90] Possums (i.e. common brushtail possum *Trichosurus vulpecula*[158]) chew on the young green flower spikes, the weight of the possum sometimes breaking the spike resulting in no seed being set.[90] Possum damage to flower spikes across five study sites ranged from around 11 percent up to 23 percent, with mean estimated damage just over 14 percent.[90]

Seed set per spike ranged from 0 (animal damaged spikes) to 9174.[90] Mean seed set per spike (excluding spikes with 100 percent seed loss due to animal damage) was 2075 (n=164).[90] However, isolated plants (nearest flowering neighbour >20m away), sustained more seed predation and had an average seed set of only 66 (n=39).[90] Plants flowering mid-season generally set more seed.[90] Total seed set tended to be higher in the middle third of a spike.[90] For other *Xanthorrhoea* species highest seed set also tends to occur in the middle section of the spike.[116] On three of the four field sites in Toohey Forest, taller plants tended to have longer flower spikes and on two of the sites taller plants produced more seeds.[90] Longer flower spikes were found to set more seed.[90] Taller plants had a higher probability of flowering.[90] The fruits (capsules) normally hold up to around three seeds (mean of 1.86 seeds, n = 469).[90] One study gave seed weight on a south-east Queensland site at around 10mg, with the lightest seed on the top third of the flower spike.[90] A second study near Armidale in New South Wales gave mean seed (diaspore) weight at 18.05mg.[286] Field observations suggest *X. johnsonii* does not have an explosive seed dispersal mechanism, with most seed falling close to the parent plant.[90] Secondary dispersal has not been determined, but the seed can float, which would allow further dispersal during heavy rain.[90] No animal seed dispersers have been identified for *X. johnsonii*. Field trials on North Stradbroke Island investigating seed removal by ants found the seeds of *X. johnsonii* were not collected by ants.[196]

The germination temperature range for *X. johnsonii* seeds from south-east Queensland was 13–31°C in laboratory trials where moisture was not a limiting factor.[90] In these trials the optimum germination temperature range was found to be 18–27°C, with no germination (within 30 days) at temperatures below 9°C and above 35°C.[90] The estimated developmental zero temperature was 6°C.[90] Earliest radicle emergence was eight days, with germination rates of 50 percent in about 12–13 days and 80 percent within 14 days.[90] Heavier seeds generally had a higher germination rate than lighter seeds.[90] Fastest germination was at 24°C, the germination success rate at this temperature being 75–100 percent.[90] Using seeds from three south-east Queensland plants, laboratory trials at 21°, 24° and 27°C found germination rates of seeds from the top third of the spike were significantly lower than seeds from the middle and lower thirds of the spike ($p<0.05$).[90] The trials also found that heavier seeds generally have a higher germination rate than lighter seeds.[90] In the field, seedling establishment in Toohey Forest is limited, but the reason/s why is/are not known, even though laboratory trials show temperature and seed viability should not be a limiting factor in the first summer after flowering.[90]

Field and laboratory germination trials have also been carried out on *X. johnsonii* seeds from the Armidale area of New South Wales.[285,286] In these trials laboratory germination in a 12/12 hour light/dark cycle and a corresponding 25/15^{o}C temperature cycle light was 20.0 percent, while in dark conditions germination was 53.7 percent.[286] For smoke treatment (smoke water) of seeds in a 12/12 hour light/dark cycle and a corresponding 25/15^{o}C temperature cycle, germination was 37.5 percent.[286] In the field trials where germination rates were also better for buried seed compared to surface-sown seed.[285] Field sown *X. johnsonii* seeds showed a strong dormancy effect with few seedlings emerging until approximately 10 weeks after sowing, seedlings still emerging up to 18 months after they were sown.[285] *X. johnsonii* seed stored in paper bags at room temperature after insect treatment with CO_2, were 100 percent viable 3–6 months after collection and 88.7 percent viable at 29–54 months after collection.[286] See sections **2.7.3** and **4.7.3.2** for additional information on seedling recruitment and survivorship post-fire.

No information was found (estimate or otherwise) on current and past numbers of *X. johnsonii* in Queensland. In Toohey Forest, south-east Queensland, *X. johnsonii* densities varied between the five study sites, the highest density 0.6 plants m^{-2}.[90] The age structure at this highest density site was characterised by large numbers of immature plants.[90] The age structure on some of these study sites suggest that recruitment is patchy in both space and time.[90]

X. johnsonii is predominately an outcrossing species.[90] In terms of genetic variability the levels of heterozygosity measured in *X. johnsonii* on the Toohey Forest study sites were relatively high and within the range for other long-lived perennial species with a mixed mating system in temperate to tropical regions.[90] Although pollen transfer is high, genetic differentiation between some study sites suggests pollen and seed are not widely dispersed, or at least it was the case in the past, and that gene flow is limited.[90] One possible reason for this observed genetic differentiation is that not all adult plants in the population studied flowered annually, with seeds from each flowering season the result of pollination between plants potentially isolated in time.[90] Smaller populations are more susceptible to higher levels of self pollination (selfing).[90] When addressing questions related to genetic variability and reproductive effort in long lived species like *X. johnsonii*, not only should mating system parameters be considered but also environmental conditions.[90] The most important parameters are those affecting pollen movement within a population.[90] What constitutes a minimum viable population or metapopulation (i.e. populations connected by significant gene flow) is still unknown for this species. However, a minimum effective population size (N_e) of about 500 breeding individuals is frequently touted as necessary to avoid long-term loss of genetic variation.[360,361,362,363]

2.6.0 Usage

Between 1995 and 1998 it was reported that 8,879,958 *X. johnsonii* leaves, 5280 flower spikes (inflorescences) and 780 whole plants were officially harvested from the wild and exported from Queensland.[13] During this same period an additional 10,059,785 leaves, 3080 flowers and 300 whole plants of unspecified *Xanthorrhoea* species were officially wild harvested and exported,[13] a proportion of these expected to be *X. johnsonii*. The calculated weight of *Xanthorrhoea* leaves exported during this period was approximately 49 tonnes based on known and estimated leaf weights.[302,334] From 1995 to 1998 the official export of cultivated *X. johnsonii* whole plants and parts from Queensland included 200 seedlings in 1996, 300 plants in 1997, 90,000 leaves (≅ 0.2 tonne) in 1997 and 300 plants in 1998.[13] In 1997 an additional 300 cultivated unidentified *Xanthorrhoea* species were officially exported,[13] but the proportion that were *X. johnsonii* is unknown.

In the Queensland 2003–4 protected plants harvest season (1 April 2003 to 30 March 2004), the quota for the taking of non-salvage *Xanthorrhoea* plants was 36,000, and during this period, 26,600 were reported as taken.[177] During the same period an additional 37,389 *Xanthorrhoea* plants were reported taken under salvage permits.[177] At least 18,389 of these salvage harvested and 23,118 of the non-salvage harvested plants were *X. johnsonii*.[177] In the 2003–4 season, non-salvage harvest of *X. johnsonii* was mainly by one harvester in the Maryborough area.[201] There is no information on the size and age of *X. johnsonii* taken. The quota for the taking of non-salvage *Xanthorrhoea* plants was reduced by 25 percent for the Queensland 2004–5 harvest season.[177]

Currently a significant amount of *X. johnsonii* foliage is being harvested in Queensland. The harvested foliage is used in the cut flower industry as a floral filler, mainly for export.[202,271] Foliage harvest in Queensland is dominated by two harvest companies.[202,274] Between the two harvesters a total of at least 41.9 tonnes of *X. johnsonii* foliage was estimated to have been harvested in the 2003–4 harvest season.[202,274,334] To derive this harvest tonnage the harvest returns that were recorded as leaf bunches were converted into weights using data from *X. johnsonii* harvest monitoring plots maintained by the major foliage harvest company in Queensland.[334] Harvest tonnage for the main harvest company in Queensland is based on leaf bunches prepared for sale, not what was actually harvested.[274] Therefore the harvest tonnage for this company is an underestimate of the amount of foliage actually harvested, as there is substantial wastage in preparing the bunches for sale.[274]

Although there is information on the current use of *Xanthorrhoea* for things such as mining rehabilitation, woodturning, pollen and nectar for honeybees and usage by Aborigines and early settlers (see **4.6.0** of this report), none specifically identifies *X. johnsonii*. However, it would be surprising if none of this usage involved *X. johnsonii*, as it is the most widely distributed *Xanthorrhoea* in Queensland and New South Wales.

2.7.0 Impact of harvesting and land management

This section details the:

1. Impact of harvesting and various land management activities on *X. johnsonii*;
2. Environmental impact of harvesting *X. johnsonii*, including impact on associated animals; and
3. Impact of *X. johnsonii* on land use (e.g. grazing).

2.7.1 Harvesting

2.7.1.1 Impact on *X. johnsonii*

Apart from data examining the impact of foliage harvest on green leaf biomass (See section **2.8.0** for detail, especially Figure 3), no information was found on the impact of harvesting wild populations of *X. johnsonii*, whether for foliage, inflorescences, seeds or whole plants. Analysis of *X. johnsonii* data from foliage harvest monitoring plots set up and measured by Cedar Hill Flower and Foliage Pty Ltd found mean leaf biomass did not significantly vary between unharvested and annually harvested plants in any year between 1998 and 2003 ($p = 0.137–0.947$), when an average of just under a quarter of the leaves were taken annually from harvested plants.[334] However, there are problems with sample sizes and possible precision and accuracy of the data used to reach this conclusion (see section **2.8.0** for details).

2.7.1.2 Impact on environment

There is no published information on the environmental impact of harvesting *X. johnsonii*. However, it is known to occur in 39 Queensland regional ecosystems where the biodiversity and/or vegetation management status is either "endangered" or "of concern" (Table 1). Tables 2 and 3 list invertebrates and vertebrates known to use *X. johnsonii*. Based on animals listed in association with *Xanthorrhoea* in Tables 8 and 9 (see section **4.7.1 2**), further species can be expected to use *X. johnsonii*. Larvae of the moth *Meyriccia latro* bore into *X. johnsonii* flower spikes and can damage developing seeds causing significant seed loss.[90] The native bee *Trigona carbonaria* is a common visitor to the flowers to gather pollen and nectar, and is suspected to be an important pollinator.[90] The introduced honey bee *Apis mellifera* also forage on the flowers.[90] *Trigona carbonaria* will forage on *X. johnsonii* over most of the day with main activity after 9.30am, peaking around 11am.[90] *Apis mellifera* forages early in the day over approximately a four-hour period.[90]

Twenty-one species of Coleoptera (beetles) have been recorded in association with *X. johnsonii* at two Brisbane sites.[3] Of these, seven were reported to be strongly associated, with at least two known to only breed in the trunks or inflorescences, their adult stages feeding on the leaves.[3] The remaining 14 species were not considered to be as strongly associated, some using the leaves for mating purposes, others to undergo procrypsis, others using the leaf bases as over wintering sites and some appearing to be only incidental visitors.[3] The largest number of associated beetle species was recorded in September and October.[3] One of the beetles claimed to be strongly associated, *Crioceris fuscomaculatus* (=*Lilioceris bakwelli*[216]),[3] maybe an error, for its adults and larvae are known to feed on the hard-leaved monocot vine *Smilax australis*.[216]

Table 2: Invertebrates known to use *Xanthorrhoea johnsonii*. * = introduced species; N = no rare or threatened status in Queensland, although some species may not occur in Queensland.

SCIENTIFIC NAME	COMMON NAME	ANIMAL TYPE	QLD STATUS	USE/LOCATION	LITERATURE REFERENCE
Aethyssius viridis	alleculid beetle	Beetle	N	Adults resting on outer leaves	3
*Apis mellifera**	honey bee	Bee	N	Adults feed on pollen and nectar	90
Ascesis australis	-	Beetle	N	Adult resting on or amongst leaves	3
Brachycaulus klugi	-	Beetle	N	Adult resting on outer leaves	3
Cleptor inermis	-	Beetle	N	Adult resting on leaves	3
Conoderus sp. 1	click beetle	Beetle	N	Adult mating and resting sites	3
Conoderus sp. 2	click beetle	Beetle	N	Adult mating and resting sites	3
Cryptocephalus argentatus	leaf beetle	Beetle	N	Adults mating on leaf	3
Cryptocephalus dichrous	chrysomelid beetle	Beetle	N	Adults resting on outer leaf	3
Curculionidae (species unknown)	weevil	Beetle	N	Borer in cordex	158
Danaus chrysippus petilia	lesser wanderer	Butterfly	N	Adults feeding on nectar	158
Danaus plexippus	wanderer	Butterfly	N	Adults feeding on nectar	158
Depsages solandri	longicorn beetle	Beetle	N	Adults feed on bases of young leaves	3
Diplocoelus xanthorrhoae	-	Beetle	N	Adults amongst leaves	3
Euploea core corinna	common crow	Butterfly	N	Adults on flowers	158
Figulus regularis	stag beetle	Beetle	N	Adults in central core of a dead, burnt trunk. Adults and larvae in decaying cortical tissue of a dead trunk.	170
Harmonia conformis	ladybird beetle	Beetle	N	Adult among young leaves	3
Hololepta sidnensis	-	Beetle	N	Adult amongst young leaves. Adults in top of decaying caudex or between it and outer sheath.	3 55
Iridomyrmex sp.	-	Ant	N	On flowering spike	158
Lilioceris bakewelli (*Crioceris fuscomaculata* in cited reference)	-	Beetle	N	Adults usually amongst young leaves	3
Melanitis leda bankia	evening brown	Butterfly	N	Adults on flowers	158
Melobasis cuprifera	jewel beetle	Beetle	N	Adult resting on outer mature leaves	3
Meyriccia latro (jun. syn. *Hylaletis latro*)	-	Moth	N	Larvae bore into flower spike and damage developing seeds	90
Micropoecila breweri	-	Beetle	N	Larvae in decaying inner caudex	55
Myrmecia sp.	bull ant	Ant	N	On flowering spike	158
*Octatoma scabripennis**	lantana beetle	Beetle	N	Adults among young leaves (over wintering site?)	3
Oxydema major (jun. syn. *Notiosomus xanthorrhoeae* and *Tranes xanthorrhoeae*)	weevil	Beetle	N	Adult amongst young leaves;	3
Paropsis ornata	-	Beetle	N	Adult resting on outer leaves	3
Paropsis sp.	-	Beetle	N	Adult on outer leaves	3
Paropsis trifasciata	-	Beetle	N	Adult resting on outer leaves	3
Rattus fuscipes	Bush rat	Rodent	C	Nesting and cover under ground-level foliage skirts.	354
Scaphidium punctipenne	-	Beetle	N	Adults resting on outer leaves	3
Tirumala hamata hamata	blue tiger	Butterfly	N	Adults feeding on nectar	158
Trigona carbonaria	stingless bee	Bee	N	Adults feed on pollen and nectar	90
Trigonotarsus rugosus	weevil	Beetle	N	Adults amongst young leaves	3
Vanessa kershawi	Australian painted lady	Butterfly	N	Adults on flowers	158
Xylocopa bombiliformis (jun. syn. *Lestis bombiliformis*)	carpenter bee	Bee	N	Nest in dead flower scapes.	307

Table 3: Vertebrates known to use *Xanthorrhoea johnsonii*.
* = introduced species; Queensland conservation status: C = common; E = endangered.

SCIENTIFIC NAME	COMMON NAME	ANIMAL TYPE	QLD STATUS	USE/LOCATION	LITERATURE REFERENCE
Bos spp.*	cattle	Bovidae (domestic stock)	-	Feed on young inflorescences. Feed on leaves & inflorescences.	109, 110, 111 112
Petaurus breviceps	sugar glider	Arboreal marsupial	C	Nectar	8
Petaurus gracilis	mahogany glider	Arboreal marsupial	E	Feed on nectar, pollen, unopened flowers and exudate from young scapes	2, 4, 8
Platycercus adscitus	pale-headed rosella	Bird	C	Feed on seeds on flower spikes	158
Pogona barbata	common bearded dragon	Lizard	C	On flower spike	158
Trichoglossus chlorolepidotus	scaly-breasted lorikeet	Bird	C	Feed on seeds on flower spikes	158
Trichosurus vulpecula	common brushtail possum	Arboreal marsupial	C	Chew young green flower stems	158

Table 3 shows both reptiles and possums will use *X. johnsonii*. The flowers are an important source of nectar and pollen for the endangered[2,4] mahogany glider *Petaurus gracilis*,[5,8] at a time of the year when other regular food resources are unavailable.[5] The glider has also been observed eating the unopened flowers.[8] The mahogany glider also consumes *X. johnsonii* exudate.[8] The young flower stalks (scapes) are chewed either near the base of the scape or near the base of the flower spike, resulting in exudate oozing from the wound.[8]

2.7.2 Grazing

2.7.2.1 Impact on *X. johnsonii*

In north Queensland cattle are known to feed “with apparent relish” on the young flower spikes of *X. media* (=*X. johnsonii*).[111] It is also reported that cattle can eat or damage the young inflorescences of *X. johnsonii* where the endangered mahogany glider *Petaurus gracilis* occurs in north Queensland.[5] What impact this feeding and damage to inflorescences has on seed output is unknown but could be significant at a local level. Fire management practices associated with cattle grazing have the potential to impact on *X. johnsonii* (see section **2.7.3**).

2.7.2.2 Impact of *X. johnsonii* on stock

Xanthorrhoea species can poison cattle, the most likely species to cause poisoning are considered to be *X. johnsonii* and *X. fulva*.[97] *Xanthorrhoea johnsonii* has been reported poisoning cattle in the Townsville district in north Queensland and the Dalby and Warwick districts of southern Queensland.[112] See section **4.7.2.2** of this report for details on *Xanthorrhoea* poisoning.

2.7.3 Fire

Although *Xanthorrhoea* foliage is considered very inflammable,[104,117] and arborescent plants can accumulate large amounts of fuel,[12,104] *X. johnsonii* appears to be relatively fire-tolerant based on the fire history and survivorship curve for populations studied in Toohey Forest.[10] However, there have been no formal studies on fire related mortality either to its seeds, seedlings, young or adult plants. No published data was found on the age at which seedlings become fire-tolerant. Nevertheless, young seedlings have a contractile primary root, which draws the vulnerable apical meristem below ground giving some protection from fire.[143,357]

Leaf production in *X. johnsonii* was elevated for at least 240 days after a fire.[10] Up to 200 and 240 days post-fire, mean leaf production was two per day (n=10).[10] By 600 days post fire, daily mean leaf production had dropped to one per day and at >1800 days post-fire was <0.9 per day.[10] Flowering can occur without fire,[356] but fire can cause a significant increase in the proportion of *X. johnsonii* flowering in the first flowering period post-fire.[10,90,356] In the second flowering season following a fire, very low numbers of plants were found to flower,[90] which is similar to the post-fire flowering pattern in *X. glauca* subsp. *angustifolia*.[104] Although flowering in other *Xanthorrhoea* species increased in the first flowering season following a fire,[11,12,102,103,104,105,116,136,143,156,161] in two *Xanthorrhoea* species, flowering peaked in the second year post-fire.[155,323] What aspect of fire induces increased flowering in *X. johnsonii* is still unclear.

Fire affects seedling recruitment in *X. johnsonii*. In a post-fire study of seedling recruitment for coastal heathland plants in northern New South Wales following September fires, *X. johnsonii* seedlings did not appear until the second year post-fire.[242] Prior to the fires the study sites were unburnt for 9–16 years.[242] High numbers *X. johnsonii* seedlings were produced, but by year three post-fire only round 40 percent remained.[242] *Xanthorrhoea johnsonii* was classified as a facultative resprouter i.e. recovery from fire by seedlings and resprouts.[242]

See section **4.7.3.2** of this report for a review of the impact of fire on other *Xanthorrhoea* species.

2.7.4 Clearing

There is no published information that explicitly assesses the impact of clearing on *X. johnsonii* populations in Queensland. However, about one-third of the 112 Queensland regional ecosystems in which it occurs have either an “endangered” or “of concern” conservation status because of clearing. Although *X. johnsonii* are protected from clearing in a significant number of conservation reserves, the high number plants salvage-harvested (over 18,000 in the 2003–4 harvest season[177]) suggests clearing is still a potential threat elsewhere.

2.7.5 Timber harvesting

No published information was found on the impact of timber harvesting operations on wild populations of *X. johnsonii*.

2.7.6 Other

No published information was found on the impact of other land use and management practices on wild populations of *X. johnsonii*.

2.8.0 Threats, population health, conservation and management

No threatening processes were identified in the literature for *X. johnsonii*, but fragmentation of populations through clearing/removal/poisoning may be a cause for concern. Isolated *X. johnsonii* plants (nearest flowering neighbour >20m away), will sustain more seed predation and have a significantly lower average seed set.[90] Loss of flowering plants may affect outcrossing rates, which are important to maintain genetic variability.[90]

In Queensland the levels of illegal take of *X. johnsonii* inflorescences, foliage and whole plants are unknown, and their impact is consequently also unknown. There is little information on the impact of legal harvesting of whole plants, foliage, seeds and inflorescences on the long-term viability of populations and associated animals. Under current EPA guidelines, foliage harvesters in applying for a harvest licence must demonstrate harvesting is ecologically sustainable.[205] Harvesters must also have access to appropriate levels of scientific expertise and resources to carry out continuing research, development and monitoring of harvesting activities.[205]

To meet their monitoring obligations, Cedar Hill Flower and Foliage Pty Ltd (main Queensland foliage harvester) has been measuring impact of *Xanthorrhea* foliage harvest on research plots in Queensland since 1996.[328,350] A second Queensland harvester had past *Xanthorrhoea* monitoring plots, but data for these sites could not be obtained. Cedar Hill recently provided summary data and analysis from its monitoring plots.[328,350] The company concluded that harvested *Xanthorrhoea* plants respond well to current foliage harvest regimes and that no detrimental effects were observed.[350] A concern is that its *X. johnsonii* data has not been independently verified for accuracy and precision, sample sizes are small and some of the measures used appear inappropriate to show foliage harvest is ecologically sustainable and not impacting on the plant. One of its measures of the impact of foliage harvest was its effect on plant growth. Although growth is a reasonable variable to assess impact, its growth measure was not a standard measure for growth in arborescent *Xanthorrhoea*. The annual growth used by the company was change in plant height measured from the ground to the tip of the tallest leaf stretched vertically above the trunk.[328] Normally only trunk length is measured to determine growth in arborescent *Xanthorrhoea*.[10,11,12,241] The “trunk plus foliage” height measure used by Cedar Hill was in some instances extremely variable from year to year on individual plants. For *X. johnsonii* this variation was as high as 83cm between years.[350] As trunk height increase should only be around 1cm per year,[10] this variation is probably because of annual differences in the length of the tallest foliage. Because annual trunk height increase is low it will take several years of trunk height measurement to determine if foliage harvest affects growth.

Annual comparison of mean leaf numbers on harvested and unharvested *X. johnsonii*, and change in mean weight of harvested leaves, was analysed and presented as supportive evidence by Cedar Hill that foliage harvest has no impact on *X. johnsonii*.[350] However, using these two variables to calculate a leaf biomass might be a better way to determine the long-term impact of foliage harvest. This author has combined the Cedar Hill total leaf and leaf weight data sets for *X. johnsonii* to determine leaf biomass.[334] Figure 3 compares mean leaf biomass in *X. johnsonii* between unharvested and annually harvested plants on monitoring plots measured annually from 1997 to 2003. Mean annual leaf take from harvested plants was 23.64 percent (n=138; range: 10.4–50.2; 95 percent confidence limit: 1.02).[334] Each yearly leaf biomass mean in Figure 3 combines measurements from individual plants on up to four plots in south-east Queensland. Measurements were combined because sample sizes were statistically inadequate from individual plots. The precision and accuracy of Cedar Hill field measurements are unknown, as they were not independently verified. Cedar Hill reports that experimental bias could have occurred because different staff have been used to conduct annual censuses on research plots.[350] With these caveats on the Cedar Hill data, analysis found mean leaf biomass did not significantly vary between unharvested and annually harvested plants in any year between 1998 and 2003 ($p = 0.137–0.947$), when an average of just under a quarter of the leaves was taken annually from harvested plants.[334] The mean foliage biomass of 1073g on harvested plants in

1997 were highly significantly lower (p = 0.000015) than the mean of 1817g for harvested plants from 1998 to 2003 combined.[334] It is unknown whether the 1997 data is an aberration related to measurement inconsistency, or is an accurate measurement of eaf biomass. The mean leaf biomass for unharvested plants in 1997 (n=10) was also low at 1493g (Figure 3). Apart from leaf harvest, plot management like fire can affect leaf biomass. EPA fire history data[353] indicates at least one of the three plots on which the 1997 foliage measurements were taken was burnt a few months prior to measurement. This fire would have affected *Xanthrrhoea* leaf biomass on the burnt plot.

The problem of low sample sizes in the Cedar Hill monitoring plot data[329,350] is largely because sections of the EPA harvest monitoring guidelines[205] are poorly worded and ill conceived for setting up scientific monitoring plots to evaluate the impact of *Xanthorrhoea* foliage harvest. The guidelines stipulate a minimum sample size of 20 plants (10 control, 10 treatment plants) per plot,[205] this far too low for adequate statistical analysis. Taking into account low sample size, inappropriate measurement variables and possible lack of measurement precision and accuracy, it is obvious current Cedar Hill data sets[350] are at best very limited in providing answers to what threat foliage harvest might have on sustainability of *X. johnsonii* populations. They provide no answers on the impact on associated animals and on flowering and reproduction. If sustainability cannot be demonstrated then a switch to the harvest of nursery-grown *Xanthorrhoea* is an option that should be considered to meet public demand for the plant. In nursery conditions, *X. johnsonii* can be grown from seed to flowering stage in about 5–6 years.[261]

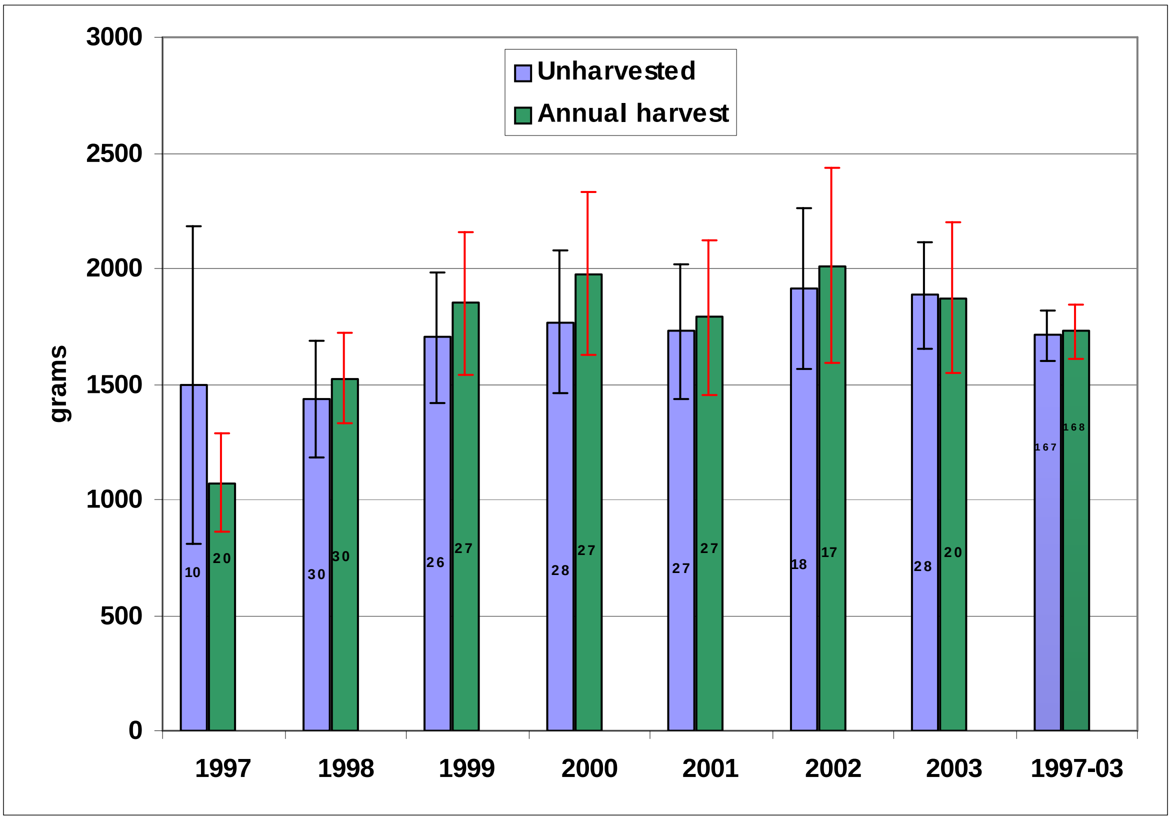


Figure 3: Annual comparison of mean leaf biomass for unharvested and annually harvested *X. johnsonii* from foliage harvest monitoring plots in south-east Queensland between 1997 and 2003. Sample sizes and 95 percent confidence limits are marked.

If harvesting is to be ecologically sustainable then knowledge of the health of current populations is essential. There is however no such information available for *X. johnsonii* populations on freehold and leasehold land. Although *X. johnsonii* is recorded from 42 national parks, five conservation parks, four resource reserves, 21 forest reserves, 41 State forests, 11 timber reserves, 19 parcels of State land and one parcel of Commonwealth land,[118] its status and health on these is also unknown. Populations in endangered regional ecosystems have protection from broad-scale clearing, but can still be affected by grazing, inappropriate fire management and weed invasion. The high salvage-harvest figures for *X. johnsonii* (over 18,000 in the 2003–4 harvest season[177]), suggest clearing on privately managed lands maybe a significant conservation issue for the plant, and requires further investigation.

Populations within protected areas managed by the EPA are essentially safe from clearing, but threats from inappropriate fire management and possibly fungal disease, animal seed predation and weed invasion may require ameliorative management. If fire regimes are inappropriate there may be long term impacts on populations of *X. johnsonii*. Fire frequency, intensity and timing may affect such things as flowering and seedling survival. Fire has been shown in other arborescent *Xanthorrhoea* species to cause significant deaths in adult plants.[101,104,218,323,325] (see sections **4.7.3.2** and **4.8.2**). The root rot fungus *Phytophthora cinnamomi* is known to fatally infect *Xanthorrhoea*,[264] and has significantly reduced some *Xanthorrhoea* populations in southern States (see section **4.8.2**). Currently there is no information on the impact of the fungus on *X. johnsonii*. However, to date there is no obvious evidence that the fungus is dramatically affecting *Xanthorrhoea* in Queensland,[338,339] in spite of the fungus being present in Queensland and causing rainforest dieback.[336,337] There is a need to monitor the impact of the fungus on *X. johnsonii* across Queensland, especially within protected areas managed by the EPA, as protected area populations are the only ones guaranteed safe from clearing.

Seed predation by the larvae of the moth *Meyriccia latro* can result in the loss of entire seed sets on plants,[90,155] but the impact of this predation on population recruitment is unknown. Possums can destroy or break flower spikes with up to 23 percent of *X. johnsonii* flower spikes showing possum damage on study sites in Toohey Forest, south-east Queensland.[90] Weeds, including invasive grasses, may smother young plants or affect fire intensity. Both the impact of weeds and animals require further investigation.

3.0 *Xanthorrhoea latifolia* (A.T. Lee) Bedford

COMMON NAME: No common name

QUEENSLAND CONSERVATION STATUS: Common, Type A Restricted[1]

COMMONWEALTH CONSERVATION STATUS: Not listed as threatened[2]

3.1.0 Distribution

There are two subspecies, *Xanthorrhoea latifolia* subsp. *latifolia* and *X. latifolia* subsp. *maxima*.[6,7,143,227] *Xanthorrhoea latifolia* subsp. *latifolia* occurs in eastern Australia from about Innisfail in north Queensland to around Wyong in New South Wales.[7,18] See Figure 4 opposite for Queensland distribution of *X. latifolia* subsp. *latifolia*. The plant occurs on a number of island groups off the central Queensland coast.[18] The subspecies *X. latifolia* subsp. *maxima* occurs in northern New South Wales on the summit of Mt Warning, and in Whian Whian and Mebbin State Forests.[7,143] Although *X. latifolia* subsp. *maxima* is not recorded in Queensland, it could occur on rhyolite-derived soils of the McPherson Ranges.[6]

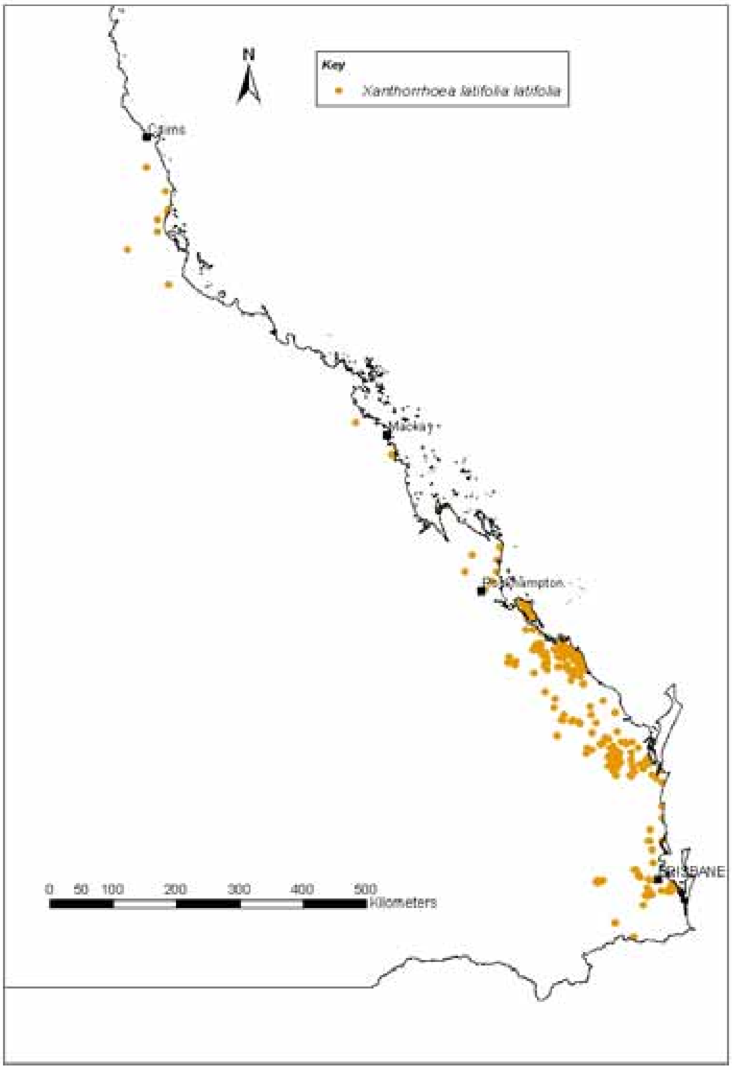


Figure 4: Queensland distribution of *Xanthorrhoea l. latifolia*.[149]

3.2.0 Description

A perennial[7] plant with or without an arborescent stem (trunk) to 2m in height,[6,143] occasionally taller[6]. The stem can be branched or unbranched.[6] The flower spike is from approximately half as long to almost equal the length of the flower scape (= stem, stalks).[143] The scapes are 100–210cm long (100–200cm[6]),[143] and have a diameter of 10–16mm.[6,143] The spikes are 50–120cm long,[6,143] their diameter 21–33mm (20–35mm[6]).[7] Leaves are green and 2.5–6mm wide (2.4–5.7mm[143]).[6] In cross section the leaves are rhombic to triangular to nearly flat.[6] Mean number of green leaves for unharvested *X. l. latifolia* on harvest monitoring plots near Mackay Queensland was 491 (s.d. 181; range 240–816; n=40).[334] Mean leaf weight for unharvested *X. latifolia* subsp. *latifolia* from the same monitoring plots was 2.06g (s.d. 1.21; range 1.01–6.61; n=20).[334] The 3-lobed fruits (capsules) are embedded in the flower spike, each fruit containing three seeds.[17] The seeds are described by one author as dark brown,[17] but this is considered an error,[357] the seeds black.[143,357]

3.3.0 Similar species

Xanthorrhoea latifolia subsp. *latifolia* is similar to *X. latifolia* subsp. *maxima*, the later distinguished by distinctive swollen leaf bases that are sometimes dark red.[143] Many specimens of *X. latifolia* subsp. *latifolia* from Gympie to Ravenshoe have much narrower leaves than typical plants, these narrower leaf plants similar to small specimens of *X. johnsonii* or large specimens of *X. pumilio*.[143]

3.4.0 Habitat

In Queensland *X. latifolia* subsp. *latifolia* is recorded from 10–1300m altitude, growing in a number of physiographic types including coastal dunes, rocky headlands, coastal plains (including wetter soils), slopes and rocky ridges.[150] Habitats in which it has been recorded in Queensland include eucalypt forest and woodland, wallum, heath, herblands and grasslands.[14,18,215] It usually grows in sandy or gravelly soils in New South Wales,[7] and sandy or stony soils in open eucalypt forest communities in south-east Queensland.[6] In the greater Brisbane area it is reported to grow in "well-drained, shallow sandy and stony soils on ridges and mountain slopes".[17]

Xanthorrhoea latifolia subsp. *latifolia* has been recorded from 54 Queensland regional ecosystems (Table 4),[14] but can be expected to occur in more. Forty-two (78 percent) of these 54 regional ecosystems have eucalypts in or dominating the overstorey.[15] Of the regional ecosystems in which *X. latifolia* subsp. *latifolia* has been recorded, two have an "endangered" and 24 have an "of concern" vegetation management" status, while four have an "endangered" and 25 have an "of concern" biodiversity status.[15] This means over half of the regional ecosystems that *X. latifolia* subsp. *latifolia* has been recorded in are either of concern or are endangered.

Table 4: Queensland regional ecosystems in which *X. latifolia* subsp. *latifolia* has been recorded and the status[15] of these regional ecosystems in 2003.

Regional ecosystem	Vegetation management status	Biodiversity status
8.2.2a	**Of concern**	**Endangered**
8.3.1b	**Of concern**	**Endangered**
8.12.13a	**Of concern**	**Of concern**
8.12.14	Not of concern	No concern at present
8.12.14a	Not of concern	No concern at present
8.12.29b	**Of concern**	**Of concern**
11.2.3af	**Of concern**	**Of concern**
11.3.25	Not of concern	**Of concern**
11.10.2	Of concern	**Of concern**
11.11.3	Not of concern	No concern at present
11.11.7	Not of concern	**Of concern**
11.11.15	Not of concern	No concern at present
11.12.3	Not of concern	**Of concern**
11.12.6	Not of concern	No concern at present
12.2.6	Not of concern	No concern at present
12.2.8	Not of concern	No concern at present
12.2.11	Not of concern	No concern at present
12.3.3	**Of concern**	**Of concern**
12.3.12	**Of concern**	**Of concern**
12.3.13	**Of concern**	**Of concern**
12.3.14	**Of concern**	**Of concern**
12.5.1	Not of concern	No concern at present
12.5.2	**Endangered**	**Endangered**
12.5.3	**Endangered**	**Endangered**
12.5.4	Not of concern	No concern at present
12.5.5	**Of concern**	**Of concern**
12.5.10	Not of concern	No concern at present
12.9-10.2	Not of concern	No concern at present
12.9-10.3	**Of concern**	**Of concern**
12.9-10.4	Not of concern	No concern at present
12.9-10.17	Not of concern	No concern at present
12.9-10.19	Not of concern	No concern at present
12.9-10.20	**Of concern**	**Of concern**
12.9-10.21	Not of concern	No concern at present
12.9-10.24	**Of concern**	No concern at present
12.11.5	Not of concern	No concern at present
12.11.6	Not of concern	No concern at present

12.11.7	Not of concern	No concern at present
12.11.17	Not of concern	No concern at present
12.12.3	**Of concern**	**Of concern**
12.12.4	Not of concern	No concern at present
12.12.5	Not of concern	No concern at present
12.12.6	**Of concern**	**Of concern**
12.12.7	Not of concern	No concern at present
12.12.9	**Of concern**	**Of concern**
12.12.10	**Of concern**	**Of concern**
12.12.11	Not of concern	No concern at present
12.12.12	**Of concern**	**Of concern**
12.12.19	**Of concern**	**Of concern**
12.12.21	**Of concern**	**Of concern**
12.12.22	**Of concern**	**Of concern**
12.12.23	Not of concern	No concern at present
12.12.24	**Of concern**	**Of concern**
12.12.27	**Of concern**	**Of concern**

3.5.0 Biology and ecology

No published information was found on *X. latifolia* stem (trunk) growth rate. See sections **2.5.1** and **4.5.2** for growth rates of other *Xanthorrhoea* species. The calculated average biomass of live leaves on unharvested *X. latifolia* subsp. *latifolia* from harvest monitoring plots in McCartney and Conway State Forests in the Mackay region was 1044g (range 404–1683g; n = 60).[334]

Flowering in New South Wales is from March to October.[7] In south-east Queensland flowering is reported to be from April to September (autumn to spring[6]).[17] Queensland Herbarium records report flowering in July and August in the Moreton district, June to October in the Port Curtis District, June, August and November in the South Kennedy District and April and May in the North Kennedy District.[150] There is no published information on flower pollinators. No information was found on seed size, production, maturation, viability, predators and germination. See sections **2.5.2** and **4.5.2** for information on flowering and seeds for other *Xanthorrhoea*.

There was no published information on population age-structure, mortality and recruitment. No figures were found on population size, but in south-east Queensland it is reported as very common on a site on the saddle between the Mt Barney peaks, and common on a site in Great Sandy National Park.[150] Also it has been reported as common on Outer Newry Island, Newry Islands National Park, near Mackay,[150] and from the holotype location at Beerwah in south-east Queensland.[357] Metapopulations (i.e. populations connected by significant gene flow) have not been identified. What constitutes a minimum viable population or metapopulation is also unknown. However, a minimum theoretical 500 breeding individuals is frequently touted as necessary to avoid long-term loss of genetic variation.[360,361,362,363]

3.6.0 Usage

From 1995 to 1998 there was no official export of cultivated *X. latifolia* subsp. *latifolia* from Queensland.[13] However, 58 wild harvested *X. latifolia* subsp. *latifolia* plants were officially exported from Queensland in 1997.[13] During the period 1995 to 1998 an additional 10,059,785 stems (leaves), 3080 flowers and 300 whole plants of unspecified *Xanthorrhoea* species were officially wild collected and exported from Queensland.[13] The proportion of these *Xanthorrhoea* that were *X. latifolia* subsp. *latifolia* is unknown. In 1997 it was reported that 300 cultivated *Xanthorrhoea* species were officially exported,[13] but the proportion that were *X. latifolia* subsp. *latifolia* is also unknown.

In the Queensland 2003–4 protected plants harvest season (1 April 2003 to 30 March 2004), the quota for the taking of non-salvage *Xanthorrhoea* plants was 36,000, and during this period, 26,600 were reported taken.[177] During the same period an additional 37,389 *Xanthorrhoea* plants were reported taken under salvage permits.[177] The proportion of these harvest totals that were *X. latifolia* subsp. *latifolia* is unknown, but of the 37,389 salvage-harvested *Xanthorrhoea*, at least 9929 were *X. latifolia* subsp. *latifolia*.[177,202] There is no information on the size and age of *X. latifolia* subsp. *latifolia* taken. There is also a significant amount of *X. latifolia* subsp. *latifolia* foliage currently being harvested in Queensland. *Xanthorrhoea* foliage is used in the cut flower industry as a floral filler.[202,271] The harvest of *X. latifolia* subsp. *latifolia* foliage is dominated by two harvest companies.[202,274] Between the two harvesters a total of at least 131.4 tonnes of *X. latifolia* subsp. *latifolia* foliage was estimated to have been harvested in the 2003–4 harvest season.[202,274,334] To derive this harvest tonnage, the harvest returns that were recorded only as leaf bunches were converted into weights using data from *X. latifolia* subsp. *latifolia* harvest monitoring plots maintained by the major foliage harvest company in Queensland.[334] Harvest tonnage for the main harvest company in Queensland are based on leaf bunches prepared for sale, not what was actually harvested.[274] Therefore the harvest tonnage for this company is an underestimate of the amount of foliage actually harvested, as there is substantial wastage in preparing the bunches for sale.[274] Prior to the 2003–4 harvest season *X. latifolia* subsp *latifolia* foliage was less intensively harvested; however, there had been a recent preference shift in *Xanthorrhoea* species harvested by the major foliage harvesting company in Queensland.[274]

Although there is information on the current use of *Xanthorrhoea* for mining rehabilitation, woodturning, pollen and nectar for honeybees, and usage by Aborigines and early settlers (see **4.6.0** of this report), none specifically identifies *X. latifolia* subsp. *latifolia*. However, it would be surprising if none of this usage involved *X. latifolia* subsp. *latifolia*, as it is widespread in eastern Queensland.

3.7.0 Impact of harvesting and land management

This section details the:

1. Impact of harvesting and various land management activities on *X. latifolia*;
2. Environmental impact of harvesting *X. latifolia*, including impact on associated animals; and
3. Impact of *X. latifolia* on land use (e.g. grazing).

3.7.1 Harvesting

3.7.1 1 Impact on *X. latifolia*

Apart from limited data examining the impact of foliage harvest on green leaf biomass (See section **3.8.0** of this report for details, especially Figure 5), no information was found on the impact of harvesting wild populations of *X. latifolia*, whether for foliage, inflorescences, seeds or whole plants. Analysis of *X. latifolia* subsp. *latifolia* data from foliage harvest monitoring plots set up and measured by Cedar Hill Flower and Foliage Pty Ltd, found mean leaf biomass did not significantly vary between unharvested and annually harvested plants in both 2003 ($p = 0.193$) and 2004 ($p = 0.284$), when a 1/3 of the leaves were taken annually from harvested plants.[334] However, there are problems with sample sizes and possible precision and accuracy of the data collected (see section **3.8.0** of this report for details).

3.7.1 2 Impact on environment

No published information was found on the environmental impact of harvesting wild populations of *X. latifolia*. However, it is known to occur in 29 Queensland regional ecosystems where the biodiversity and/or vegetation management status is either "endangered" or "of concern" (Table 4). No vertebrates or invertebrates have been recorded in the literature in association with *X. latifolia*. However, many animals can be expected to be associated with the plant based on species known to use other *Xanthorrhoea* (see section **4.7.1.2**).

3.7.2 GRAZING

3.7.2.1 Impact on *X. latifolia*

No published information was found on the impact of grazing on wild populations of *X. latifolia*.

3.7.2.2 Impact of *X. latifolia* on stock

No published information was found on the impact of wild *X. latifolia* on domestic stock and associated land management.

3.7.3 Fire

Fire has been recorded stimulating flowering in *X. latifolia*.[102] No other published information was found on the impact of fire on wild populations of *X. latifolia*. See sections **2.7.3** and **4.7.3.2** for the impact of fire on other *Xanthorrhoea* species.

3.7.4 Clearing

There is no published information on the impact of clearing on *X. latifolia* subsp. *latifolia* populations in Queensland. However, 29 of the 54 Queensland regional ecosystems in which it occurs have either an "endangered" or "of concern" conservation status because of clearing.

3.7.5 Timber harvesting

No published information was found on the impact of timber harvesting operations on wild populations of *X. latifolia*.

3.7.6 Other

No published information was found on the impact of other land use and management practices on wild populations of *X. latifolia*.

3.8.0 Threats, population health, conservation and management

No threatening processes were identified in the literature for *X. latifolia*, but fragmentation of populations through clearing/removal/poisoning may be of concern (see section **2.8.0** of this report). In Queensland the levels of illegal take of *X. latifolia* subsp. *latifolia* inflorescences, foliage and whole plants are unknown, and their impact is consequently also unknown. There is little information on the impact of legally harvesting whole plants, foliage, seeds and inflorescences on the long-term viability of populations and associated animals. Under current EPA guidelines, foliage harvesters in applying for a harvest licence must demonstrate harvesting is ecologically sustainable.[205] Harvesters must also have access to appropriate levels of scientific expertise and resources to carry out continuing research, development and monitoring of harvesting activities.[205] To meet these obligations Cedar Hill Flower and Foliage Pty Ltd (main foliage harvester in Queensland), has been monitoring the impact of *Xanthorrhea* foliage harvest on research plots in Queensland since 1996.[328,350] Their monitoring of foliage harvest impact on *X. latifolia* subsp. *latifolia* only commenced in 2003.[350] Recently they provided summary data and analysis from their monitoring plots,[328,350] and rightly concluded that two years of data was insufficient to draw strong conclusions on the impact of harvesting *X. latifolia* subsp. *latifolia*.[350] They suggest at least five years of data would be needed to draw reasonable conclusions.[350]

In addition to Cedar Hill's concern about interpreting only two years of data, I have concerns that field measurements have not been independently verified for accuracy and precision, that sample sizes are too small and that some measures are either inappropriate or not the most appropriate to show foliage harvest is ecologically sustainable and doesn't affect the plant. The precision and accuracy of Cedar Hill field measurements are unknown, as they have not been independently verified. Cedar Hill reports that experimental bias could have occurred because different staff have been used to conduct annual censuses on their *Xanthorrhoea* research plots.[350]

One Cedar Hill assessment of the impact of foliage harvest was its effect on plant growth. Although growth is a reasonable variable to assess impact, their growth measure was not a standard measure for growth in arborescent *Xanthorrhoea*. The annual growth measure they used was change in plant height measured from the ground to the tip of the tallest leaf stretched vertically above the trunk.[328] Normally only trunk length is measured to determine growth in arborescent *Xanthorrhea*.[10,11,12,241] The 2003 and 2004 *X. latifolia* subsp. *latifolia* "trunk plus foliage" height measures taken by Cedar Hill show significant variation for a number of plants between the two years.[350] This variation was as high as 218cm.[350] This variation is probably because of annual differences in the length of the tallest foliage, as trunk height increase should only be around 1–2cm per year.[10,12,104,241] Because annual trunk height increase is low, it will take several years of only measuring trunk height to determine if foliage harvest affects growth in *X. latifolia* subsp. *latifolia*.

The 2004 Cedar Hill *Xanthorrhoea* monitoring research report also had an annual comparison of the mean number of leaves on harvested and unharvested *X. latifolia* subsp. *latifolia* and the change in mean weight of harvested leaves.[350] However, combining these two variables to calculate a leaf biomass might be a better way to determine long-term impact of foliage harvest on foliage production. This author has combined the two variables to determine leaf biomass.[334] Figure 5 compares mean leaf biomass in *X. latifolia* subsp. *latifolia* between unharvested and annually harvested plants on monitoring plots measured in 2003 and 2004. Mean percentage of leaves taken annually from harvested *X. latifolia* subsp. *latifolia* was 33.3 percent (n=40; range: 33.1–33.3; 95 percent confidence limits: 0.02).[334] Each yearly leaf biomass mean in Figure 5 combines measurements from individual plants on two plots from near Mackay in south-east Queensland. Measurements were combined because sample sizes were statistically inadequate from individual plots. Analysis of this limited data found mean leaf biomass did not significantly vary between unharvested and annually harvested plants in both 2003 ($p = 0.193$) and 2004 ($p = 0.284$), when a 1/3 of the leaves were taken annually from harvested plants.[334]

The problem that plot sample sizes are too low is largely because of current EPA harvest monitoring guidelines.[205] Sections of these guidelines are poorly worded and ill conceived for setting up scientific monitoring plots to evaluate the impact of *Xanthorrhoea* foliage harvest. The guidelines stipulate a minimum sample size of 20 plants (10 control, 10 treatment plants) per plot,[205] which is far too low. Taking into account low sample size, inappropriate measurement variables and possible lack of precision and accuracy, it is obvious current monitoring data sets will at best provide limited answers on what threat foliage harvest poses to the sustainability of populations. The data sets will provide no answers on the impact of foliage harvest on flowering and reproduction and on animals associated with the plant. If sustainability cannot be demonstrated then a switch to the harvest of nursery-grown *Xanthorrhoea* is an option that should be considered to meet public demand for the foliage. In nursery conditions *Xanthorrhoea* can be grown from seed to flowering stage in about 5–6 years.[261,262]

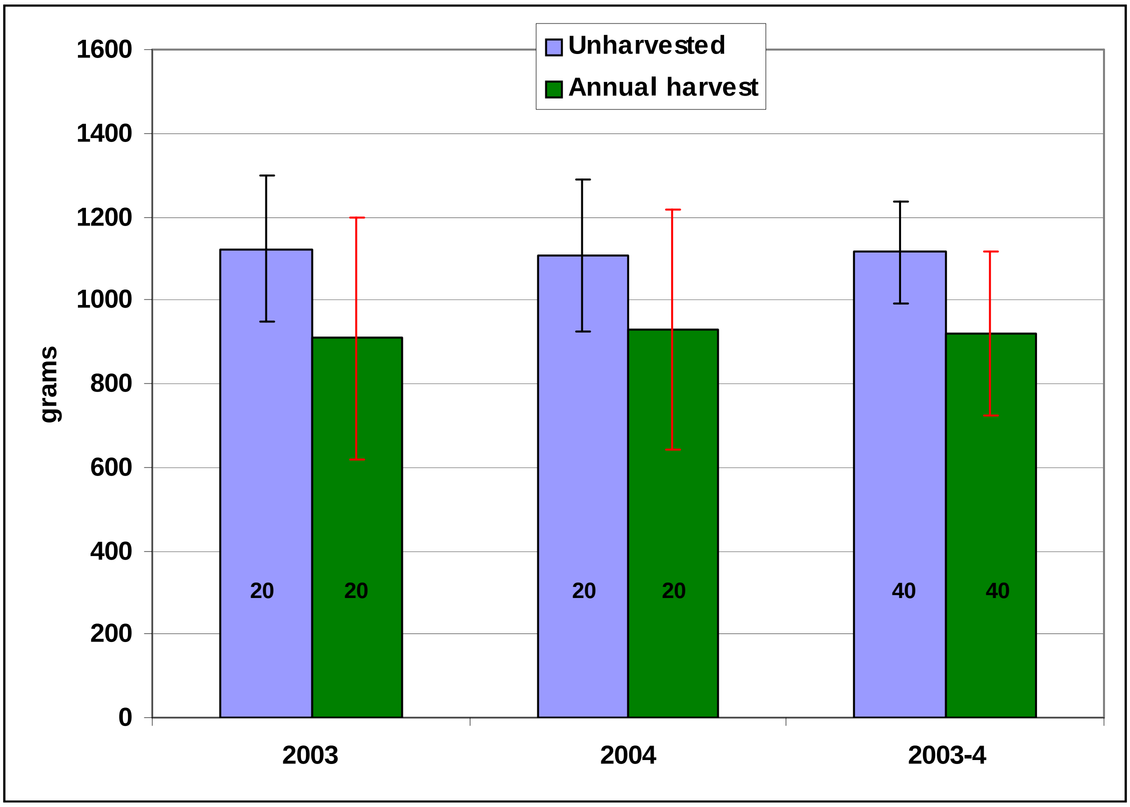


Figure 5: Annual comparison of mean leaf biomass for unharvested and annually harvested *X. latifolia* subsp. *latifolia* from foliage harvest monitoring plots near Mackay, Queensland for 2003 and 2004. Sample sizes and 95 percent confidence limits are marked.

If harvesting is to be ecologically sustainable then knowledge of the health of current populations is essential. However, there is no information on the current health of populations on freehold and leasehold land. Although *X. latifolia* subsp. *latifolia* is recorded from 21 national parks (includes six island national parks), three conservation parks, 19 forest reserves, and 16 State forests,[151] its status and health on these is also unknown. Populations within these protected areas still require appropriate fire management and possibly weed management. Outside these protected areas, populations occurring in endangered regional ecosystems have protection from broad-scale clearing, but can still be affected by grazing and inappropriate fire management, and possibly fungal disease and weed invasion.

Although *X. latifolia* subsp. *latifolia* is afforded protection from broadscale clearing in threatened regional ecosystems, current salvage-harvesting (nearly 10,000 *X. latifolia* subsp. *latifolia* in the 2003–4 harvest season[177]), suggests clearing on privately managed lands may still be a significant conservation issue for the plant. Populations within protected areas managed by the EPA are essentially safe from clearing, but threats from inappropriate fire management and possibly fungal disease and weeds may require ameliorative management. The impact of weed species such as lantana and exotic grasses is unknown, especially the impact on seedling establishment and survival. Weeds may impact on fire intensity.

On whatever land tenure *X. latifolia* subsp. *latifolia* occurs, inappropriate fire regimes could be a major threat. Fire frequency, intensity and timing may affect such things as flowering and seedling survival. Fire has been shown in other arborescent *Xanthorrhoea* species to cause significant deaths in adult plants.[101,104,218,323,325] See sections **4.7.3.2** and **4.8.2** for further details on the impact of fire on *Xanthorrhoea*.

The root rot fungus *Phytophthora cinnamomi* is known to fatally infect *Xanthorrhoea*,[264] and has significantly reduced some *Xanthorrhoea* populations in southern States (see section **4.8.3**). There is no information on the impact of the fungus on *X. latifolia* subsp. *latifolia*. In fact there are no reports or observations that the fungus is dramatically affecting any *Xanthorrhoea* in Queensland,[338,339] in spite of the fungus occurring in Queensland where it causes rainforest dieback.[336,337] There is a need to monitor the impact of the fungus on *X. latifolia* subsp. *latifolia* across Queensland, including within protected areas managed by the EPA.

4.0 Additional *Xanthorrhoea* information

4.1.0 Distribution

Twenty-eight *Xanthorrhoea* species including five subspecies are recognised in Australia, and belong to the endemic plant family Xanthorrhoeaceae.[143,219] Their distribution extends through south-western, southern, central and eastern Australia and includes Tasmania.[143] They occur in all States and mainland Territories.[219] With the exception of one species, all occur in regions with rainfall >250mm per annum, in most regions >500mm.[143,227] The majority of species have very limited ranges and are often in isolated clumps within their range.[219]

4.2.0 Description

Xanthorrhoea can have an arborescent trunk, subterranean trunk or no trunk.[241] The linear leaves are crowded in a terminal crown.[143] While most *Xanthorrhoea* have a single crown of leaves, plants with up to 23 "heads" have been recorded.[241] Some arborescent *Xanthorrhoea* have branching trunks.[219] Trunks in some species can reach 6m (7m[320,358]) in height. [143,227]

4.3.0 Species identification

Species can rarely be identified on one or two characteristics alone, identification usually requiring the use of many characteristics.[227] Identification keys and descriptions are available for all species,[6,7,17,143] but hybridisation does occur between some species,[143,227] which can make species identification difficult in some instances[112,143]. Species involved in hybridism are *X. glauca*, *X. resinifera*, *X. fulva*, *X. johnsonii* and *X. latifolia*.[227] Hybridisation appears to be restricted to *Xanthorrhoea* species in habitats on Quaternary sand deposits along the east coast of Australia.[227] Hybridism has only been recorded where two *Xanthorrhoea* species meet on an ecocline (e.g. between wet and dry habitats).[227]

4.4.0 Habitat

Xanthorrhoea occur in a variety of soil, terrain and vegetation types.[143] Depending on species, *Xanthorrhoea* can grow in poorly drained soils that are seasonally waterlogged through to well drained soils.[143] They are also known to grow in nutrient poor soils, for example *X. australis*[162].

4.5.0 Biology and ecology

Xanthorrhoea are monocotyledonous plants (i.e. produce a single seed-leaf when they first germinate).[143,241] They are considered a very advanced and rapidly evolving plant family.[219, 227] There are still many aspects of their biology and ecology that are poorly known, with limited information on age to maturity, population numbers, age-structure, mortality, recruitment and dispersal.

4.5.1 Roots and water uptake

The roots of *Xanthorrhoea* species are contractile and will pull the apical meristem below ground level when the plant is young.[98,143] There is no tap root or major lateral roots.[308] Roots are usually unbranched and may radiate laterally several metres.[98] In older plants, new rings of roots are initiated progressively higher on the trunk, leaving a dead area below.[98] Root growth in *X. preissii* commences in winter, is highest in spring and ceases during summer.[152] This spring peak in root growth appears to be related to adequate soil moisture and rising temperatures.[241] For *Kingia australis* peak root growth was in summer.[241]

There is little information on *Xanthorrhoea* root penetration down into the soil. The roots of *X. preissii* have been recorded underground to an estimated depth of 6.4m in coastal sandy soils of Western Australia.[152] It is believed the ability of *X. preissii* to draw water from medium soil depths (>1m) and their low rate of stomatal water transpiration allows them to maintain higher internal water pressures than deep-rooted *Eucalyptus marginata* during drier summer weather in south-western Australia.[308] In coastal woodland, water uptake by *X. preissii* following 18–60mm of rain was found to occur within the top 0.3m of soil.[330] The extensive root system of *X. australis* is reported to extend down to 3m in dry health vegetation on deep sands.[332] This extensive root system and the ability of this *Xanthorrhoea* to intercept and funnel water along the leaves into the soil around the base of the plant, provides a competitive advantage during periods of drought.[332]

4.5.2 Reproduction and flowering

Information was scant and mostly anecdotal on the time it takes *Xanthorrhoea* to reach reproductive age. Many *Xanthorrhoea* species grown from seed will first flower at five to six years of age.[219] It is reported that *X. preissii* raised from seed, flowered for the first time at 10 years of age, while in the wild this species has taken as long as 124 years to first flower.[11] *Xanthorrhoea minor* from Victoria are reported to start flowering at 10 years of age.[230] The smallest *X. glauca* subsp. *angustifolia* (ex *X. australis*) to flower in a Victorian study had a trunk 0.24m tall.[218] *Xanthorrhoea johnsonii* in south-east Queensland, generally doesn't commence flowering until the trunk is about 20cm in height at about 23 years of age, with plants still flowering at 2.6m in height (ca 295 years of age) in Toohey Forest in south-east Queensland.[90] The frontispiece of this report shows a *X. johnsonii* from Yuleba State Forest near Roma in Queensland that is around 3m in height (ca 340 years of age[10]) and still flowering. The grasstree *K. australis* still flowers at 4.5m tall (ca 300 years of age).[11]

Each *Xanthorrhoea* species has a fairly well defined annual flowering period, but this flowering period can vary considerably between species.[143] In the broad-ranging *X. johnsonii* there also appears to be some variation in the flowering period across its range.[6,7,8,17,90] (see section **2.5.2**) Taller arborescent *X. preissii* and *X. glauca* subsp. *angustifolia* were found more likely to flower than shorter arborescent plants.[101,218] Fire can stimulate flowering (see section **4.7.3.2**), but fire is not always essential for flowering to occur.[12,104,155,218,222,356] Flowering not stimulated by fire has been recorded at very low levels to as high as around 30 to 55 percent of adult plants in a season.[12,155,218,356] In a Victorian stand of many thousand mature *X. australis* plants unburnt for several years, annual flowering was less than one percent.[222] In another unburnt Victorian stand of *X. australis* no inflorescences were produced over a 15 year period.[223] However on still another Victorian site that had been unburnt for about 100 years, almost 55 percent of the adult *X. glauca* subsp. *angustifolia* (ex *X. australis*) flowered in one season.[218] On this later site there were three significant pulses of flowering over a 10 year period that were not induced by fire.[218] Leaf clipping and ethylene gas treatment can also induce flowering,[12] but the impact of clipping on flowering is not clear. Clipping leaves to ground level on trunkless *X. australis* in South Australia did not induce flowering,[136] while in other studies clipping induced flowering in *X. fulva* and *X. australis*.[12,102] Flowering is reported to occur in *X. fulva*, and *X. macronema* soon after plants are slashed to ground level on firebreaks and tracks in two south-east Queensland State forests.[328]

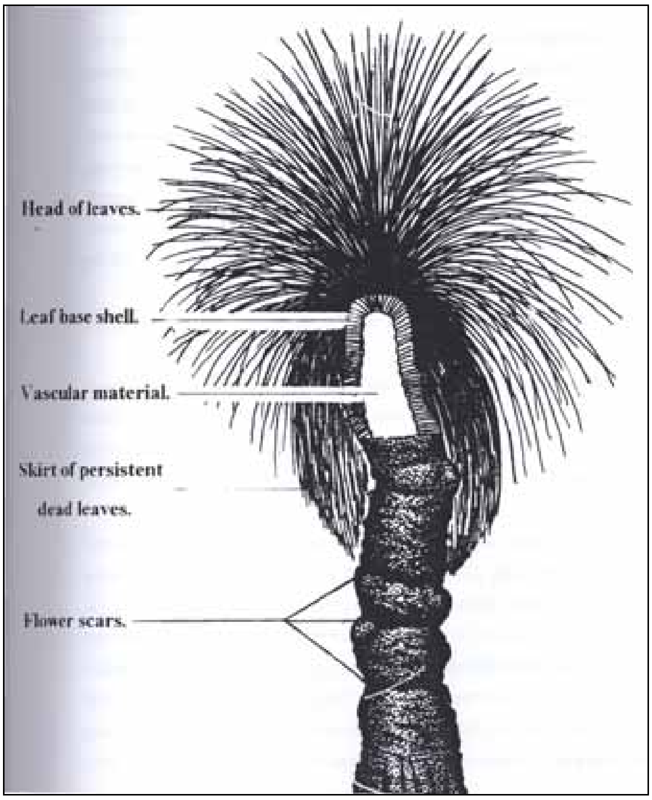


Figure 6: *Xanthorrhoea australis* sketch showing flower scar kinks in trunk.[221]

Mature *X. johnsonii* from Toohey Forest in south-east Queensland flowered on average about once every five years.[10] In at least some arborescent *Xanthorrhoea* species,[357] flowering frequency can be determined because each successful flowering leaves the trunk kinked, creates an interruption to the pattern of leaf bases on the trunk and often leaves a scar where the scape was once attached.[199] The kink forms because the growth tip dies when the plant flowers with a new growth tip developing following flowering that is slightly offset (= apical displacement) from the central axis of the trunk (Figure 6).[199] This is called sympodial growth.[357] In some arborescent species there is very little apical displacement, making sympodial growth difficult to discern.[357] For *X. preissii* it has been suggested that there might be a minimum resource threshold before the reproductive process is initiated.[342] In autumn-burnt *X. preissii*, flowering plants consistently had 1.32 times more nutrient content in their foliage compared to non-flowering plants.[241]

Xanthorrhoea inflorescences consist of cylindrical flower spikes on stout woody scapes.[6,7,143] Inflorescences in some species can reach lengths of 3m or more,[222,239] with *X. preissii* inflorescences recorded as long as 5.53m.[348] Growth of inflorescences can be rapid. One *X. hastilis* (= *resinosa*[143]) inflorescence from the Sydney area was recorded growing at a maximum rate of 10.2cm per day over a three day period, with an average growth rate over a 60 day period of 3cm per day.[235] Most growth in this inflorescence occurred at night.[235] For *X. preissii*, daily inflorescence growth can be as high as 6.8cm and averages 5.6cm.[152] The inflorescences of *X. australis* unburnt for at least two years, were recorded growing to 300cm in 75 days, an average elongation rate of 4cm per day.[222] The growth curve for these *X. australis* inflorescences was biphasic with maximum growth rates in weeks one and four after growth commenced. Maximum relative growth rate occurred in week one (i.e. percentage growth relative to length of inflorescence), but the maximum growth rate of 7cm per day (49cm over seven days) occurred in week four.[222] Although average growth rate is biphasic, there is considerable weekly variation in inflorescence growth on individual plants.[222]

Young inflorescences are usually green and rather soft, but stiffen and harden at maturity.[112] The inflorescence is photosynthetic during its growth stage, but it is daily production of photosynthates by the foliage that contributes most to inflorescence growth.[152] When light was prevented from reaching *X. preissii* foliage, the stored starch in the plant's stem was not adequate as a substitute, this evidenced by a 41 percent reduction in inflorescence biomass.[152] Although the percentage of *X. preissii* flowering increased with plant height, once flowering was initiated, inflorescence size and flower and fruit production showed no relationship to plant size.[239] A grasstree 0.25m high was found to be just as likely to support a 3m high inflorescence as a plant 1.5m high.[239] For details of the impact of fire on inflorescence production see section **4.7.3.2** of this report.

Xanthorrhoea flowers are spirally arranged on the spike.[7,143] The musk-scented[304] flowers are bisexual[7,143] and protandrous[143] (i.e. male flower parts develop before female parts), and can produce 20cal of nectar per day.[304] A *Xanthorrhoea* in full flower can produce 2.5kcal of nectar per day.[304] Although self-pollination is possible, for *X. johnsonii* it appears limited because pollinators (believed to be insects) are thought to be very efficient at removing pollen from a flower spike before the female parts mature.[90] Currently over 100 invertebrate and 45 vertebrate species are known to visit *Xanthorrhoea* flowers (Tables 7 and 8), but their role as pollinators is largely unknown. The importance of invertebrate pollinators compared to vertebrate pollinators is poorly known. There is circumstantial evidence that small dasyurid marsupials such as *Antechinus stuartii* might play an important pollination role in a number of Australian plant species.[299] *Antechinus stuartii* are known to visit *Xanthorrhoea* flowers and *Xanthorrhoea* pollen has been found in their faeces.[287] The open brush-like flowers of *Xanthorrhoea* are not considered to be highly specialized for bird-pollination.[317] However, birds in the genus *Acanthorhynchus* and *Phylidonyris* are known to carry *Xanthorrhoea* pollen, with birds in the later genus considered major pollinators of *Xanthorrhoea*.[304] The placement of *Xanthorrhoea* pollen on birds is not very localised and may be dusted all over the face as well as the undersurface of the body.[304] There is evidence to suggest that in *X. australis* seed production can be pollinator-limited.[303] Whether this is a result of anthropomorphic changes to pollinator populations or movement patterns is not known.

4.5.3 Seeds, germination and seedlings

Xanthorrhoea seeds are normally ovate in shape and semi-matt black, rarely ovoid and shining.[227] *X. australis* seeds are recorded at 9mm in length by one author,[233] and 7mm long by 3mm wide by a second author.[116] *Xanthorrhoea. glauca* subsp. *glauca* seed from Levers Plateau, Queensland, were approximately 6mm long.[227] In *X. johnsonii* the fruits (capsules) normally have up to about three seeds (mean 1.86 seeds, n = 469), seeds weighing around 10mg and seed maturation taking about three months.[90] The tricarpellary fruits of *Xanthorrhoea* species have up to eight ovules per carpel.[116] This means that potentially each fruit can produce a maximum of 24 seeds, but rarely does it exceed six seeds per fruit and often they have only one seed per carpel.[116] Average seeds per fruit combining counts from *X. australis*, *X. resinifera* and *X. preissii* was 2.1.[116]

Mean seed weight has been recorded at 14.76mg[197] and 15.47mg[195] for *X. gracilis*, 17.0mg[295] and 19.67mg[195] for *X. preissii*, 24mg[138] for *X. glauca* subsp. *angustifolia* (ex *X. australis*) and 18.05mg[286] and around 10mg[90] for *X. johnsonii*. Over 9000 seeds have been recorded on *X. johnsonii* flower spikes, with generally more seed set mid-way through the flowering season.[90] Up to 2600 seeds have been counted on *X. resinifera* flower spikes,[116] an estimated 7500 on *X. australis*,[116] and 2100–6000 on *X. preissii*.[342] Some *Xanthorrhoea* species might have more than 10,000 seeds per flower spike.[12,155] In *X. australis*, *X. resinifera* and *X. johnsonii* seed set was highest on the central sections of the flower spike.[90,116] Although large numbers of seed can be produced seed predation can also be considerable. Predation of *X. australis* and *X. johnsonii* seeds by the larvae of the moth *Meyriccia (Hylaletis) latro* can result in the loss of entire seed sets on plants.[90,155]

Seed development has been poorly documented. From emergence of the inflorescence to seed release took 4.5–5 months in *X. preissii* in south-western Western Australia.[152] Seed release and germination for *X. fulva* in New South Wales occurred within 12 months of flowering.[102] *Xanthorrhoea fulva* plants burnt in October 1994 had fully developed inflorescences by August 1995, and had released most seed in the summer of 1995–96.[102] By July 1996 young *X. fulva* seedlings were observed, but following this there was no further seedling establishment.[102] Given the large release of seed on this study site, seedling recruitment was low (two seedlings per $10m^2$).[102] There was evidence suggesting a large proportion of the seed was eaten by rodents.[102]

Seed fall in *X. glauca* subsp. *angustifolia* (ex *X. australis*) from north-eastern Victoria occurred 12 or 18 months after fire.[218] Most seed fell in March and April about seven months after flowering, but some remained on the flower spike through winter to be finally shed in spring.[138] *Xanthorrhoea australis* from the Australian Capital Territory did not begin seed dispersal until about 16 months after a late September fire.[12] Field observations of *X. johnsonii* suggest there is no explosive seed dispersal mechanism, most seed falling close to the parent plant.[90] *Xanthorrhoea glauca* subsp. *angustifolia* seeds also fall to the ground at maturity,[138] a Victorian study finding seedlings were usually growing within 2m of the parent plant.[104] Probably all *Xanthorrhoea* have this form of primary seed dispersal. Secondary dispersal has not been well documented for *Xanthorrhoea* species. *Xanthorrhoea johnsonii* seeds can float, which would allow further dispersal during heavy rain.[90] Ants can carry seed comparable in weight to some *Xanthorrhoea* seeds.[138] In a Victorian field trial where *X. glauca* subsp. *angustifolia* (ex *X. australis*) seeds were planted in and on various soil substrates, there was no direct evidence of ant predation.[138] No evidence was found of ants harvesting *X. fulva* seeds in a New South Wales heathland, although rodents were known to eat the seed.[102] However, in a Victorian field study where seeds of a number of plant species were laid out in dishes, about 30 percent of the *X. australis* seeds offered were removed by ants.[233] How many of these removed seeds were destroyed by the ants is unknown.[233] Removal of *X. australis* seeds by ants was in spite of the seeds having no morphological adaptations to facilitate dispersal by ants.[138] The seeds of *X. glauca* subsp. *angustifolia* (ex *X. australis*) have no morphological adaptations to facilitate dispersal by birds,[138] or adaptations to enhance burial.[218] Burial relies on the action of water, animals or leaf litter coverage.[218]

Limited published information was found on how long *Xanthorrhoea* seeds can remain viable. Based on seedling germinations in the wild, it was suggested that viable *Xanthorrhoea* seeds do not persist in the soil seed bank longer than two years.[241] Whether this is the result of seed predation is unclear. Seed viability can remain high for much longer than two years in laboratory storage. After *X. glauca* subsp. *angustifolia* (ex *X. australis*) seeds were stored five years at room temperature and humidity in insect-free, sealed, brown-paper bags without insecticide, their germination rate was not significantly different from seed stored similarly for one year.[217] The germination rate of both the five-year and one-year-old seed was in excess of 95 percent.[218] The germination rate of the five-year-old and one-year-old seeds was not significantly different, whether the seed germinated in total darkness or in a 12/12 hr $12^{o}C/20^{o}C$ temperature and light/dark cycle with an average photoflux reading of 58.4 $\mu mol.m^{-2}s^{-1}$.[218] However, total darkness induced germination earlier in five-year-old seed, while one-year-old seed germinated earlier in the light/dark cycle conditions.[217,218]

The optimum germination temperature range for *X. drummondii* from Western Australia and *X. glauca* subsp. *angustifolia* (ex *X. australis*) from north-eastern Victoria was $15–20^{o}C$.[137,138] Below $10^{o}C$, germination in *X. glauca* subsp. *angustifolia* from north-eastern Victorian was slow, with little germination until the temperature exceeded $12^{o}C$.[138] In south-western Western Australia the seeds of *X. gracilis* can germinate at $13–23^{o}C$ and *X. preissii* at $13–28^{o}C$.[195] The optimum germination temperature range for *X. gracilis* was around $13–18^{o}C$ and for *X. preissii* $13–23^{o}C$ ($15–20^{o}C$ for *X. reflexa*[131] = *X. preissii*[357]).[195] At $13^{o}C$ and $18^{o}C$, germination of *X. gracilis* and *X. preissii* seeds was not affected by light levels (either continuous darkness or a 12 hour diurnal light period).[195] At $23^{o}C$, germination in both species was inhibited in the 12 hour light regime, but not in continuous darkness.[195] This indicates that at higher temperatures (summer period), the moistened seeds of both species need burial to germinate.[195] This could lead to better seedling survival, as buried seed would be expected to have better moisture conditions than seeds lying on the surface.[195]

In a variable temperature regime with an average temperature close to the optimum, *X. glauca* subsp. *angustifolia* seeds germinated earlier than seeds germinated at a constant optimum temperature.[138] Moistened *X. reflexa (= X. preissii*[357]*)* seeds at 15–20°C took 7–23 days to germinate with an average seed viability of 49 percent.[31] Induced dormancy occurs in *X. glauca* subsp. *angustifolia* at 30°C[138] and 35°C in *X. gracilis*[197], with germination occurring when the temperature fell to favourable levels.[138,197] It was suggested that dormancy of *X. gracilis* seeds at 35°C maybe a mechanism to prevent germination during the occasional summer thunderstorms in its Western Australia habitat.[197] There is little information on field germination times. Field sown *X. australis* seeds are reported to take 21 days to germinate in the Geelong District of Victoria,[232] although sowing depth, temperature and pre-treatment were not detailed. See section **2.5.2** of this report for germination temperatures for *X. johnsonii*. For information on seedling survival and further information on germination see section **2.7.3** and the last paragraph of section **4.7.3.2**.

Once germinated, all *Xanthorrhoea* seedlings develop contractile roots that draw the apical meristem (growing tip) down.[143] The apical meristem of *X. australis* can be drawn up to 12cm below ground,[12] while in *X. resinifera* it can draw down as far as 23cm.[294] Glasshouse-grown *X. australis* seedlings had apical meristems drawn down up to 1cm per month.[155,290] In the field, draw-down rates appear to be much slower.[290] The contraction process ceases when a stem hits a barrier (e.g. rock) or stem size is too large for the roots to pull it down further.[290]

4.5.4 Growth, longevity and deathrate

There is limited published information on growth and longevity in *Xanthorrhoea*. Grasstrees appear to have continuous but seasonally variable leaf growth.[152,241,329, 331,333] Leaf production in *X. preissii* from south-western Australia is continuous but seasonally variable, with a mean of 590 leaves produced annually in jarrah forest habitat.[329] This is similar to mean annual live leaf counts for *X. l. latifolia* of 491 (s.d. 181; range 240–816; n=40) and 668 (s.d. 284; range 148–1680; n=167) for *X. johnsonii*.[334] For unburnt *X. preissii*, mean leaf production ranged from 2.5–3.2 leaves per day from late-spring to autumn, to as low as 0.5 leaves per day in winter.[152] Lowest leaf production recorded was 0.17 leaves per day.[152] Low soil moisture can slow *X. preissii* leaf production.[152] A mean daily temperature of 20°C marks the threshold between slow and fast leaf growth.[152] Immediately following fire, leaf production accelerates in *X. preissii* regardless of season,[152] although growth was most vigorous in spring-burnt plants.[241] Growth was also more vigorous in *X. preissii* burnt early autumn than those burnt in late autumn when cooler temperatures restrict growth.[241] Examination of a number of factors potentially behind this accelerated growth found fire ash and reduced shade can significantly increase leaf growth.[152] However, their effects were small compared with the stimulation of leaf growth by leaf clipping, which increased leaf growth by 26 percent.[152,241] The minerals necessary for the growth flush in *X. preissii* after a spring burn comes from stored reserves in the trunk, while minerals leached from the ash are sufficient for the growth flush following an autumn burn.[342] Nitrogen and potassium levels can rise significantly in post-fire foliage regrowth compared with unburnt plants.[241] Stored starch may also be important to leaf growth. The annual peak in starch reserves within the trunks of *X. preissii* coincides with the most fire-prone time of the year.[241] Other factors like inflorescence development can influence leaf growth. In *X preissii*, the period from emergence of the flower spike to seed release 4.5–5 months later can result in up to a 4.6 times reduction in leaf production compared to non-flowering plants.[152]

Although the rate of leaf elongation in *X. preissii* was not as seasonally consistent as leaf production, it generally increased in late winter/early spring and was coincident with mean daily temperatures of around 12°C.[152] Leaf longevity for *X. australis* in the Australian Capital Territory on shaded and unshaded sites was 2.8 and two years respectively.[12] For *X. preissii* in south-western Australia, leaf longevity for leaves produced in summer was about two years and for winter-produced leaves was about 2.5 years.[152,329] The leaves of unburnt *X. preissii* took 1.3 to 1.6 years to reach maturity with leaves produced in summer reaching maturity earlier.[152] Death of *X. preissii* leaves was always in summer,[152,312,329] and coincided with the annual peak in leaf production and elongation.[152] For *X. reflexa* (= *X. preissii* or *X. drummondi*[143]), the timing and age of dying leaves was similar.[333] Annual leaf production by mature unburnt *X. preissii* balanced with the leaf death rate (400–600 leaves annually), resulting in no substantial change in leaf area.[152] Fire appears to affect leaf longevity in *X. preissii*. The youngest surviving leaves on a burnt plant died on average 4–5 months earlier than equivalent leaves on unburnt plants.[152,241]

During development of the inflorescence and consequent flowering and fruiting, the grasstree's vegetative apex (growing tip of the trunk) permanently ceases leaf production.[219] However, following flowering and fruiting, new leaf growth resumes through the sprouting of a previously inactive axillary bud to one side of the original apex (around the base of the inflorescence[241,290]).[219] This is termed sympodial growth.[241] Sometimes more than one bud is activated.[219,241] In *X. preissii* the loss of leaf production during this reproductive stage is equivalent to about 40 percent of the mean annual leaf production of non-flowering plants growing on coastal sands in Western Australia.[152]

In arborescent *Xanthorrhoea* growth is measured by trunk height increase. *Xanthorrhoea* trunks consist of a true stem (caudex) covered in persistent, densely packed leafbases.[241] A sticky resin is normally associated with the leaf-bases.[241] This resin is characteristic of the genus and gave the genus its name.[357] The trunk diameter varies forming distinct undulations, this diameter variation correlated to seasonal changes in leaf production.[11,241,329] Fire can also change trunk diameter by burning the outer portions of the leaf bases covering the caudex.[357] The rate at which trunk height increases can vary significantly. Plants with a narrow caudex grow taller at a slower rate than plants with a wider caudex.[241] Even plants growing side by side can have different growth rates.[241] In Victoria, *X. australis* with bigger trunk circumferences were found to have higher trunk-height growth rates.[199] Trunk growth rates have been determined in four arborescent grasstrees. Mean increase in trunk height for X. *johnsonii* from south-east Queensland was 0.88cm (S.D. 0.17) per year.[10] The mean annual height increase of the Western Australian grasstree *Kingia australis* was calculated at 1.52cm (range 0.66–2.45cm).[11] For *X. preissii*, another Western Australian species, growth on individual plants ranged from 0.5cm to 6cm per year,[329] with a mean growth rate of 1.2–2.6cm considered typical.[241] Mean annual height increase of *X. preissii* on what was considered a poor growth site, was approximately 0.9cm per year.[101] Others have recorded mean trunk height increases for *X. preissii* of 1.42cm per year (range 1.06–2.39cm),[11] 1.25cm per year,[329] and over 2.1cm per year.[101] Long periods between fires are reported to reduce growth rates in *X. preissii*.[349] There is some evidence to suggest that this maybe linked to reduced nutrient uptake in the absence of regular fire.[347] For *X. australis* from the Australian Capital Territory, annual trunk height increase was 0.9cm per year.[12] A.M. Gill reports the growth rate of *X. glauca* subsp. *angustifolia* (ex *X. australis*) on granitic soils in north-eastern Victoria could be up to 2cm per year.[104] Growth rates for *X. australis* can vary significantly between sites.[199] In a Victorian study, *X. australis* mean growth rates varied from 0.85cm per year in heathland to 2.08cm per year in open forest site.[199] The mean of the mean annual growth rates from 10 sites in this study was 1.39cm.[199]

More than one technique has been used to age arborescent *Xanthorrhoea*. The most commonly used is based on the annual increase in trunk height. Estimating an age for arborescent *Xanthorrhoea* is complicated because after germination, *Xanthorrhoea* develop contractile roots that draw the apical meristem (growing tip) underground.[143] In arborescent *Xanthorrhoea* species it can take some years for this apical meristem to emerge from the ground and form a trunk. The time for the trunk to emerge from the ground is poorly documented. It is reported that cultivated, seed-grown, fast-growing species of *Xanthorrhoea* can develop 10–15cm tall trunks in 10 to 15 years.[219] *Xanthorrhoea preissii* are reported to take 20 years for a trunk to emerge from the ground,[229] while *X. johnsonii* takes about 23 years to emerge from the ground and develop a 20cm tall trunk.[90] Kangaroo Island landowners and *Xanthorrhoea* resin harvesters report growth of *X. semiplana* subsp *tateana* on cleared, fertilized, pasture-sown land was faster than plants in native vegetation.[236] It was reported that it was not uncommon for plants on pasture land to have a 1m trunk after 30 years.[236]

Xanthorrhoea are long-lived plants. The tallest *X. australis* in the Australian Capital Territory were estimated to be about 350 years of age using charcoal measurements and known growth rates.[12] A 2.95m tall *X. johnsonii* from south-east Queensland was estimated to be 335 years of age based on known growth rates.[10] Extrapolating using measured growth rates, the tallest known specimens of *X. preissii* in Western Australia have been estimated by one author to be about 350 years old.[11] Radio carbon dating of four *X. preissii* 1.95–3.65m tall gave probable ages of 400–600 years.[200] The oldest of these was only 2m tall.[200] If it is assumed the trunk height of an individual *X. preissii* grows at a more or less constant rate somewhere between 1.2 to 2.6cm per year,[241] a plant with a 4m trunk that emerged from the ground at 20 years of age would be anywhere between about 175 and 355 years old. It is reported that X. *preissii* plants with thicker trunks grew faster than specimens with narrow trunks.[241] Many of the tallest *X. preissii* had thicker trunks, which indicates they were faster growers and would therefore still be in the same age-range as mature plants of more average heights.[241]

Both extrinsic (e.g. soil nutrients) and intrinsic factors (e.g. photosynthesis efficiency and photosynthate storage) influence growth and development. In *X. johnsonii* and *X. australis* maximum rate of carbon dioxide assimilation by photosynthesis is 19.9 μmol.m^{-1}.sec^{-1} and 13.5 μmol.m^{-1}.sec^{-1}[2] respectively,[266] and their carboxylation efficiencies are graphed in Figure 7. The maximum rate of photosynthesis in *X. johnsonii* as expressed by carbon dioxide assimilation, falls at the high end for "C3" type grasses and is well above most woody evergreens.[266,267] Photosynthesis in *X. australis* is higher than in most woody plants.[266] For both *Xanthorrhoea* species the emphasis appears to be on storage of photosynthate rather than immediate use in vegetative growth.[266] Carbon dioxide assimilation through photosynthesis is not uniform in the foliage. Photosynthesis was maximal in leaves greater than 40cm in length, but dropped rapidly in smaller leaves, with leaves less than 30cm long making an insignificant or negative contribution to assimilation (Figure 7).[266] Table 5 presents a breakdown of dry weight green leaf biomass relative to leaf length on two *X. australis* approximately 1m tall and unburnt for several years.

Information is scarce on natural death rates for *Xanthorrhoea*. In *X. australis* normal death rates were about 1 percent per year in arborescent plants 1–1.8m tall.[155] Arborescent *X. glauca* subsp. *angustifolia* up to 4m tall on a site unburnt for about 100 years had a death rate of 4 percent over a two year period.[104] No deaths occurred in non-arborescent plants (includes seedlings) on the same unburnt site over the two year period.[104] For the same site the adult plant death rate over a 10-year period averaged 0.7 percent per annum.[218] Death rates can accelerate significantly because of factors such as infection by *Phytophthora cinnamomi*[175,176,186,189,190,191] and fire.[104,218]

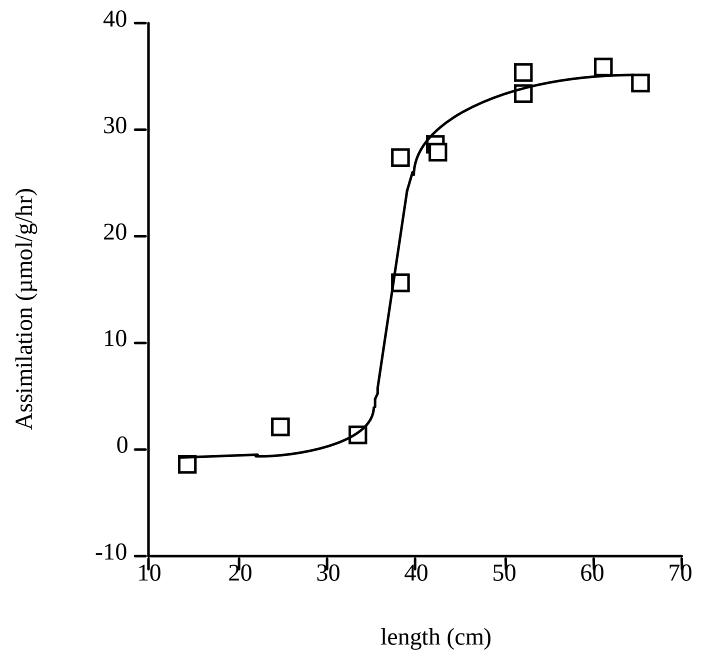


Figure 7: The relationship between leaf length and photosynthesis (CO_2 assimilation rate) in adult *X. australis*.[266]

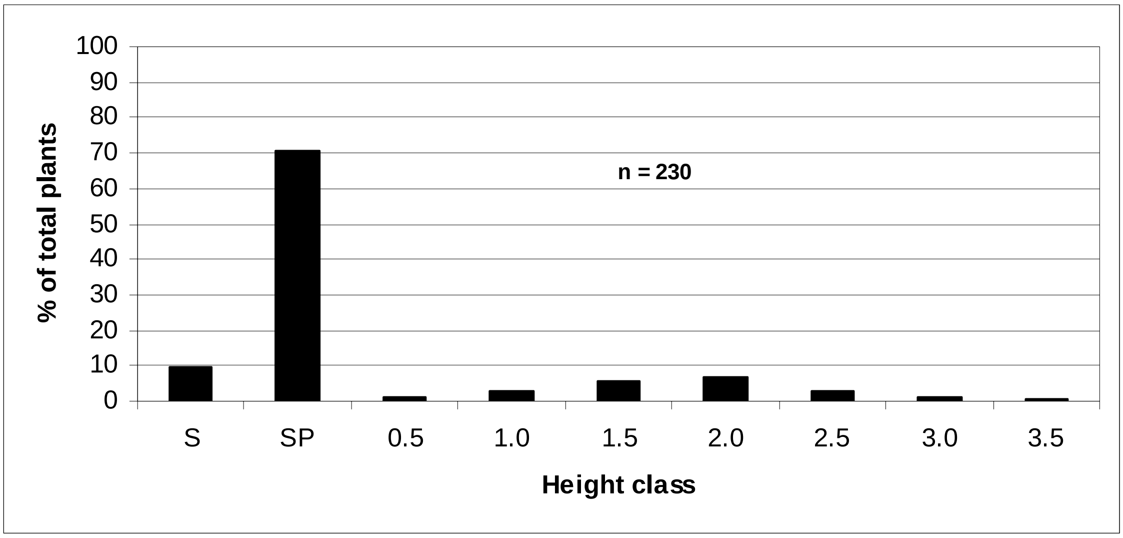
Table 5: Green leaf biomass weight distribution relative to leaf length in two adult *X. australis*.[266]

Leaf class	Total dry weight of leaf tissue (g)
Leaves >40cm	268
Leaves 30-40cm	5.4
Leaves <30cm	12.8

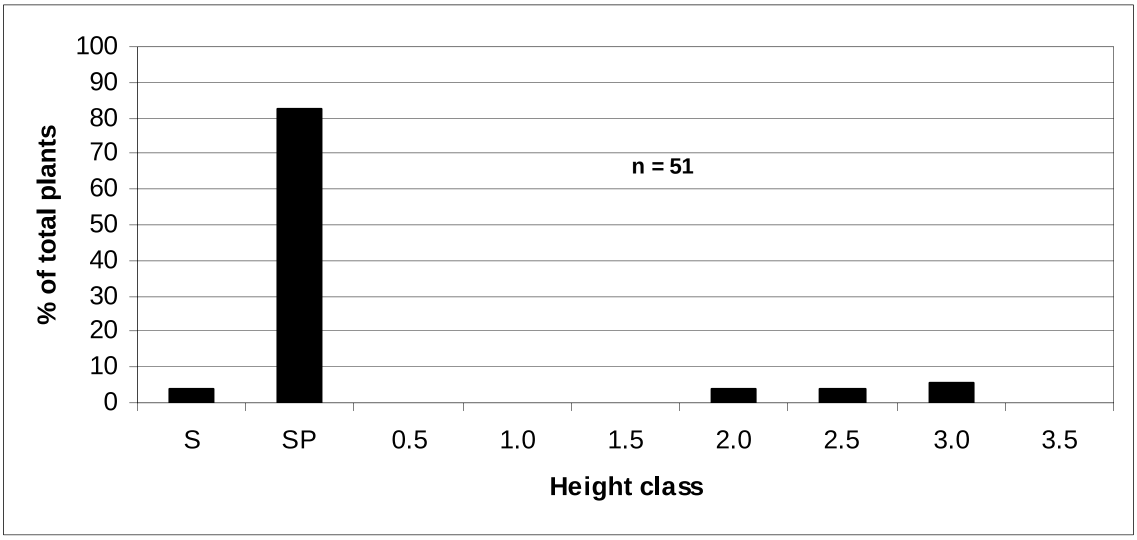
4.5.5 Population structure

What constitutes a healthy age structure for a *Xanthorrhoea* population is largely unknown. In a Victorian study,[104,218] the structure of *X. glauca* subsp. *angustifolia* populations on sites unburnt for 10, 25 and ~35 years and protected from rabbit grazing for 10 years are presented in Figure 8.

A.



B.



C.

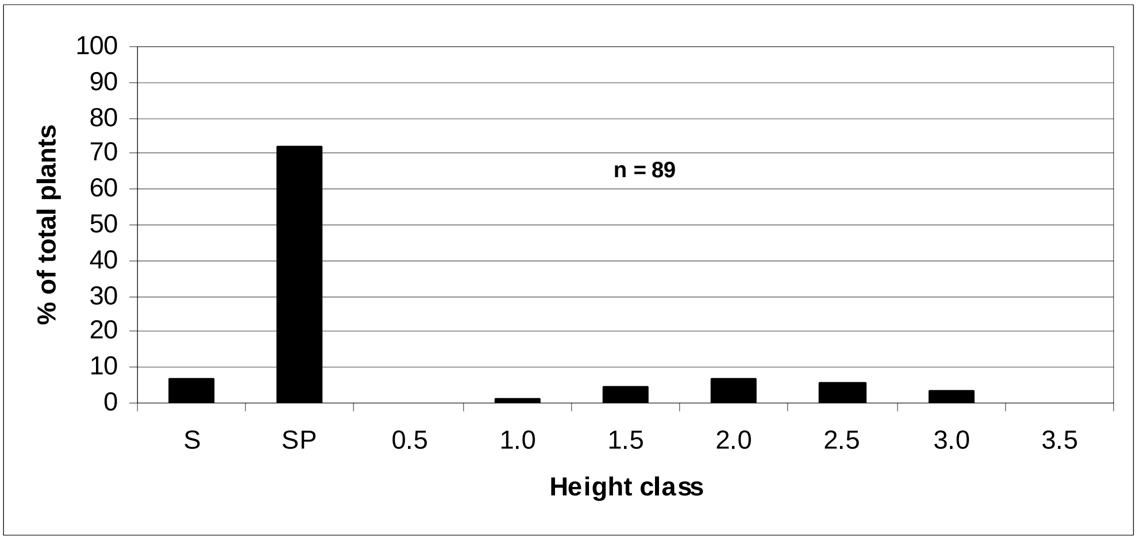


Figure 8: Structure of Victorian *X. glauca* subsp. *angustifolia* populations on sites unburnt for varying years and fenced to exclude rabbits for 10 years. **A.** 10 years unburnt; **B.** 25 years unburnt; **C.** ~35 years unburnt. **Height classes**: **S** = 3–6 leaves, ≤ 10 years old; **SP** = >6 leaves, no trunk above ground; **0.5** = trunk to 0.5m tall; **1** = trunk >0.5m to 1m; **1.5** = trunk >1m to 1.5m tall; etc.

In Figure 8, young plants with only 3–6 leaves (believed to be up to about 10 years of age[104]) on sites unburnt for 10, 25 and ~ 35 years and protected from rabbits for 10 years, constituted 9.6 percent, 3.9 percent and 6.7 percent respectively of the populations.[220] Plants with more than 6 leaves and lacking an above ground trunk were 70.4 percent, 82.4 percent and 71.9 percent respectively of these populations.[220] Plants with trunks (arborescent stages) were only 20.1 percent, 13.7 percent and 21.3 percent respectively of these populations.[220] The demographics in Figure 8 suggest few plants survive to the arborescent stages. This is supported by other studies that show high seedling mortality.[242,323,325] Because flowering and subsequent seed production can be significantly increased by fire (see section **4.7.3.2**), long periods between fire could lead to episodic well spaced peaks in seedling recruitment.

4.6.0 Usage

Xanthorrhoea species are or have been harvested from many regions of Australia for either resin, seeds, foliage, inflorescences or whole plants.[13,140,141,142,177,201,202,203,207,209,213,214] Harvested whole plants are sold domestically or are exported overseas, the domestic trade including a significant cross-state-border trade.[214] Trade in wild harvested *Xanthorrhoea* between 1995 and 1997 included *X. australis, X. fulva, X. glauca, X. gracilis, X. johnsonii, X. latifolia, X. minor, X. preissii, and X. thorntonii*.[214] Main export markets for *Xanthorrhoea* in 1997 were Singapore, Norway and Great Britain.[214] No current export data were found in the literature.

The availability of data on the harvest of *Xanthorrhoea* species varies from State to State. Detailed central data bases covering all forms of harvest (whole plants, foliage, seeds and other products) are still not set up in most States, including Queensland. For instance, Queensland information on the take of *Xanthorrhoea* whole plants is currently stored centrally, but data for foliage collection is still only stored on regional and district files.

In the Queensland 2003–04 protected plants harvest season (1 April 2003 to 30 March 2004), the quota for the taking of non-salvage *Xanthorrhoea* plants was 36,000, and during this period, 22,031 were reported taken.[177] During the same period an additional 37,389 *Xanthorrhoea* plants were reported taken under salvage permits.[177] This brings the total *Xanthorrhoea* taken for the season to 59,420, of these 36,938 were *X. johnsonii*, 9929 *X. l. latifolia*, 3687 *X. glauca* subsp. *glauca* and 8866 unspecified *Xanthorrhoea* species.[177] The Bundaberg and Maryborough areas are where most *Xanthorrhoea* are taken in Queensland.[201,202] In the 2003–4 harvest season 29,932 plants were taken from the Bundaberg area, of which 28,318 were salvage-harvested plants and 1614 non-salvage.[202] All non-salvage plants taken in the Bundaberg area during the 2003–4 season were *X. johnsonii*, while for salvage-harvested plants, 18,389 were *X. johnsonii* and 9929 were *X. latifolia*.[202] In the previous harvest season a total of 16,881 *Xanthorrhoea* plants were taken from the Bundaberg area.[202] The main harvester in the Maryborough area took 20,368 *Xanthorrhoea* in the 2003–4 harvest season.[201] For the Queensland 2004–5 protected plants harvest season, the quota for the taking of non-salvage *Xanthorrhoea* plants has been reduced by 25 percent.[177] Queensland has a tagging system for harvested whole plants.[177]

Management of *Xanthorrhoea* harvest varies across Australia. Tasmania has no restrictions or monitoring of whole plant take for non-threatened *Xanthorrhoea* on private land.[209] Although Tasmania currently has no tagging system or control on the take of non-protected *Xanthorrhoea* on private land, a management plan is being developed and export overseas is under Commonwealth guidelines.[209] Western Australia use a permit system that allows harvest of *Xanthorrhoea* whole plants under a native flora management plan for the commercial harvesting of protected flora. Except for salvage purposes, whole plant harvest is not encouraged.[213] Whole plant harvest on Western Australian Crown land is only for salvage purposes and requires special endorsement and royalties for plants harvested.[213] In Western Australia during 2003 a total of 1087 *X. preissii* were officially taken from private land and one from Crown land.[213] It was also reported that a leading commercial Perth operator salvage-harvests about 3000 *X. preissii* annually with up to 2000 of these replanted, mostly in metropolitan public places, some exported to eastern Australia and overseas.[351] There are currently no figures available on the harvest of whole plants in New South Wales (NSW), although a central database is being developed.[260] A licence and tagging system currently allows NSW pickers to take whole plants from private land not owned by the picker.[260] As part of a new management plan for the take of whole plants that is currently being drafted, this current picker licensing system is under review and could be phased out or significantly changed.[260] Currently owners of private land in NSW can harvest or propagate from *Xanthorrhoea* on their own land.[260] Plants propagated this way can only be sold under permit, but don't require tagging.[260]

In addition to *Xanthorrhoea* whole plant harvest in Queensland, a significant amount of *Xanthorrhoea* foliage is also harvested.[271] Species reportedly harvested are *X. johnsonii*,[271,274] *X. latifolia* subsp. *latifolia,*[271,274] *X. g. glauca*[271,274] and *X. fulva.*[202] The foliage is used as a floral filler in the cut-flower trade, principally for export.[202,271] In Queensland *Xanthorrhoea* foliage harvest is dominated by two permit holders.[202,271] Currently there is no central EPA database for *Xanthorrhoea* foliage harvest in Queensland, but records related to plant harvesting are kept on regional files. These records include harvest returns regularly submitted by harvest permit holders to meet permit conditions. Some of the harvest returns are recorded in kilograms, others as the number of leaf-bunches.[202,274] The bunches consist of either 50 or 100 leaves per bunch.[271] The weight of a *Xanthorrhoea* leaf bunch varies with species. For *X. johnsonii* and *X. l. latifolia* the average weight for a 100-leaf bunch is 277g [302,334] and 208g[334] respectively. Total tonnage of *Xanthorrhoea* leaves harvested in the 2003–4 harvest season by the two commercial harvesters that currently dominate the industry in Queensland was just over 207 tonnes.[202,274] Approximately 63 percent of this tonnage was *X. l. latifolia* foliage, 20 percent *X. johnsonii* and 17 percent *X. g. glauca*.[202,274] The harvest figures rely heavily on the accuracy of the returns provided by the commercial operators as there is only limited auditing of foliage harvest by the State.[202] The tonnage of foliage harvested is probably an underestimate even if harvest figures provided are accurate. The harvest tonnage for the current main harvest company in Queensland (~65 percent of market share) is based on leaf bunches prepared for sale,[274] not what was actually harvested. The amount of foliage actually harvested is expected to be significantly higher as there is substantial wastage in preparing foliage bunches for sale.[274] See sections **2.6.0** and **3.6.0** of this report for additional harvest details.

Xanthorrhoea foliage is harvested elsewhere in Australia. In Western Australia, foliage harvest for 2003 was determined to be 1,670,804 leaves.[213] Based on a leaf weight of 2.43g, this equates to approximately 4.1 tonnes. Species reportedly harvested in Western Australia in 2003 were *X. gracilis* and *X. preissii*, 96 percent from Crown land.[213] It is somewhat surprising that the foliage of *X. gracilis* is harvested as it produces few leaves compared to other *Xanthorrhoea*.[357] *Xanthorrhoea* foliage is also harvested in Tasmania and Victoria,[208,209] but no figures were available on the total amount harvested. However, in Victoria official harvest of *Xanthorrhoea* foliage, as well as flower stems, was considered to be limited, although illegal harvest is thought to be significant.[208] In Tasmania, *Xanthorrhoea* foliage is currently officially harvested from Crown land by one operator,[209] with royalties and harvesting guidelines imposed as part of permit conditions.[269] Currently there are no restrictions or monitoring of the harvest of foliage from non-threatened *Xanthorrhoea* species on private land in Tasmania.[209]

The mining industry have used *Xanthorrhoea* species as part of their seed mixes on some rehabilitation sites.[131] In 2003, 2.6kg of *X. gracilis* seeds and 17.1kg of *X. preissii* seeds were taken under permit in Western Australia.[213] Most of this seed was for rehabilitation projects.[213] The stumps and roots of xanthorrhoeas have been used for wood turning and carving.[22,23,24] It is reported that in Western Australia the stems of *Xanthorrhoea* species are much sought after by wood turners.[98] The similar *Kingia australis* (Family Xanthorrhoeaceae) is also used by wood turners in Western Australia. In 2003, a total of just over 1200kg of dead *X. preissii* trunks and burls were collected under permit in Western Australia for craftwood purposes.[213] Although *Xanthorrhoea* species are a source of pollen and nectar for honeybees, the honey is thin, rank and unpalatable.[19] Honeybees also collect resin from *Xanthorrhoea* for use in a resinous substance (propolis) bees produce for sealing cracks and spaces within the hive.[19] This propolis causes problems as it sets hard in winter making movement of frames and other hive materials difficult, while in summer it becomes sticky.[19]

Resin is harvested from *Xanthorrhoea*. Principal resin-yielding species have been *X. semiplana* subsp. *tateana*, *X. resinifera (ex resinosa)*, *X. australis* and *X. preissii*.[248] Except for *X. resinifera* all of these predominantly produce red resin.[237,248] The resin accumulates on the old leaf bases that cover the stem of the trunk,[236] consisting of an intercellular secretion from the outer cortical cells of the stem.[237] A number of constituents have been identified from *Xanthorrhoea* resin.[341]

Harvesting of resin and other *Xanthorrhoea* products was well established in Australia by the 1860s.[114] During the 19th and/or the 20th century, *Xanthorrhoea* resin was used as a polish,[46,82] photographic light filter,[249] timber varnish,[82,114,219,238,248,249,250] wood stain,[249] textile colouring,[98] medicine,[115,219] paper sizing agent,[82] and in the manufacture of soap,[82] linoleum,[249] early gramophone records,[82] picric acid,[46,98,114,219,238,248,249] alcohol[98,114,249] and sugar.[98,114,249] The resin was also burnt as incense in early churches.[82,115] The fibrous trunks were used as brake blocks in steel-tyred wagon wheels in use throughout the 1800s.[219] During World War II most cans of troop food were coated with a protective coat of *Xanthorrhoea* varnish.[250]

Table 6 summarises *Xanthorrhoea* resin export from Australia for selected years up to 1994. Prior to 1930 export figures were provided in hundredweights (1 cwt = 112 lbs),[248,249] but in Table 6 these hundred weight values have been converted to tonnes. From 1911 to 1913 most resin was exported to Germany.[249] In the financial years 1927–28 and 1928–29, 86 percent was exported to the U.S.A., Germany, U.K. or France, 28 percent to the U.S.A. alone.[248]

Table 6: *Xanthorrhoea* resin export/production from Australia for selected years. Values in tonnes.

EXPORT STATE	1911	1912	1913	1926-7	1927-8	1928-9	1939-40	1992	1993	1994
South Aust.			1301.3*	606.6♠	2423.0+ (2543.2♠)	2751.4+ (2893.7♠)	2129.6♥			
NSW			201.2*		45.2+	43.5+				0.0♣
Western Aust.			0.0*		20.1+	17.3+	343.4♥			30.0♦
Victoria			0.5*		20.4+	1.1+				0.0♣
Australia	**469.0#**	**838.9#**	**1099.5#**		**2508.7+**	**2813.3+**		**198.6♣**	**264.2♣**	**152.9♣**

* = exported, resins of all kinds (73 percent was *Xanthorrhoea* resin), reference 249
# = exported, reference 249 + = exported, references 248
♦= exported, July–September 1994, reference 236 ♣ = exported, reference 236
♠ = produced, reference 248 ♥ = exported, reference 237

Kangaroo Island in South Australia appears to be the last place in Australia where significant *Xanthorrhoea* resin harvesting still occurs.[319] No resin harvesting currently occurs in Victoria,[319] New South Wales[319] and Queensland.[274] *Xanthorrhoea* resin has been harvested from Kangaroo Island since at least the 1880s.[249] Table 7 provides figures for *Xanthorrhoea* resin export from Kangaroo Island from 1996 to 2002. Current resin harvest from the island is significantly lower than past harvest and in recent years has only been allowed from stock-piled dead plants.[296] The stock-pile is down to approximately three tonnes.[296] The harvesting company is currently going through a process with both the Commonwealth and the State to renew harvest and export of resin derived from dead plants in the wild, once the stock-pile is exhausted.[296] A February 2004 inventory of resin available from dead plants on the island was estimated at 1939 tonnes.[319] This indicates about 24 years of resin harvest is still possible based on a harvest of 80 tonnes annually.[319]

Table 7: *Xanthorrhoea* resin export from Kangaroo Island, South Australia from 1996 to 2002.[319]

Year	1996	1997	1998	1999	2000	2001	2002
Tonnes	41.85	62.25	83.5	96.5	93.9	67.7	63.8

Traditional aborigines also utilized *Xanthorrhoea* species. The plants were used to make spear handles,[20] spears,[17,81,219] fire sticks,[17,81,282] tinder for fires,[81,219] water proofing resin[17,21] and binding resin for tools such as axes.[46,98,219,250,282] Individual grasstrees were lit as signal fires.[344] The leaves were used to cut meat.[282] *Xanthorrhoea* were also an Aboriginal food source. Food included nutritious starch,[20] shoots,[20] tubers of young plants and young leaves,[282] roots,[81] grubs[20] and nectar from the flowers.[46,282] Nectar was extracted by dipping the inflorescences in water to produce a sweet drink.[46]

4.7.0 Impact of harvesting and land management

This section details:

1. The impact of harvesting and various land management activities on *Xanthorrhoea;*
2. The environmental impact of harvesting, including impact on associated animals; and
3. The impact of *Xanthorrhoea* on land use (e.g. grazing).

4.7.1 Harvesting

Harvesting of *Xanthorrhoea* whole plants or parts is conducted under a Queensland management plan for protected plants that is effective until 2005.[205] A similar management plan is used for *Xanthorrhoea* harvest in New South Wales. This plan is also effective until 2005.[206]

4.7.1.1 Impact on harvested species

Population Viability Analysis (PVA) on the impact of harvesting a long-lived plant like *Xanthorrhoea* requires field studies of long duration and large sample sizes if good estimates of mortality, recruitment and population growth are to be determined.[364] This is necessary as time within each life-stage can be long, making life-stage transition probabilities difficult to determine.[364] If the minimum effective population size is about 500 breeding plants, as is frequently touted as necessary to avoid long-term loss of genetic variation,[360,361,362,363], and breeding plants were assumed to make up only about 20 percent of a population (see section **4.5.5** of this report), then a minimum viable population would need to be at least 2500 plants. This is based only on maintaining genetic variability and takes no account of what a minimum population size should be to avoid extinction based on normal demographic and environmental stochasticity or the occurrence of catastrophic events such as severe drought or wildfire.[361,362]

The only information found on the impact of harvesting *Xanthorrhoea* were two plant harvesting scenarios applied to two population models for *X. resinifera* under study in New South Wales.[323] Both models were simulations over a 100-year time frame starting with 1017 plants.[323] The initial population structure consisted of 207 seedlings, 343 juvenile and sub-adult plants and 467 adult plants,[324] giving an effective population (number of breeding plants) of 467. The first model (base model) was founded on a population with exposure to disease and fire.[323] The second model was for a best-case scenario, and simulated a disease-free population exposed to fire.[323] See Figure 10 in section **4.7.3.2** for further detail on the two models. A single harvest of 100 adult plants mid-way through the 100-year simulations reduced the average expected minimum population size (EMP) for the base and best-case scenario models by eight percent and 17 percent respectively.[323] Harvesting one adult plant per year for 100 years reduced the EMP for the base and best-case scenario models by six percent and 1.5 percent respectively.[323] When these simulation models only take into account the effective population size (number of breeding plants) at the start and finish of the 100-year simulations, the impact of harvesting is more severe. A single harvest of 100 adult plants (= 21 percent of adult plants at the start of the simulation) mid-way through the 100-year simulation, reduced the average effective population size for the base and best-case scenario models by 15.5 percent and 27.0 percent respectively.[324] Harvesting one adult plant per year for a 100 years reduced the average effective population size for the base and best-case scenario models by 12 percent and 12.5 percent respectively.[324] Therefore both harvest scenarios, regardless of the model, caused a drop in the effective population size (number of breeding plants), but with harvesting having least effect on final adult population size when done at the rate of one adult plant per year over the 100-year simulations. Even if these models had shown no decline in effective population size, a 100-year simulation may not necessarily distinguish between a stable population and one declining towards extinction in species where life expectancy can considerably exceed 100 years.[364] *Xanthorrhoea resinifera* probably can live significantly longer than 100 years, based on the 300+ year life expectancy of other *Xanthorrhoea*. PVA models for *Xanthorrhoea* species currently harvested in Queensland need to be developed for various harvesting scenarios over simulation times of 100+ years.

The impact of *Xanthorrhoea* foliage harvest is poorly known and has not been modelled for any species. For non-arborescent *X. fulva*, the complete clipping of foliage to within 5cm of the ground induced flowering, although burning induced more.[102] The *X. fulva* inflorescences produced following clipping were significantly shorter with significantly less seed set than unclipped, burnt plants.[102] The reason for this is not clear. However, when light was prevented from reaching the leaves of *X. preissii* (equivalent of clipping effect on photosynthesis), the stored starch in the plant's stem was not adequate as a substitute for inflorescence development, as evidenced by a 41 percent reduction in inflorescence biomass.[152]

Clipping can affect xanthorrhoeas in other ways. The clipping of *X. australis* foliage was found to influence flowering, the response dependent on the time clipping occurs.[155] Leaf clipping of *X. australis* in the Australian Capital Territory in May and August induced a poor flowering response in the first year post-clipping,[155] while clipping in November,[55] February[155] and early October[12] increased flowering. *Xanthorrhoea australis* clipped in early October commenced growing inflorescences three months early than unclipped unburnt controls.[12] Plants burnt in early October also commenced growing inflorescences three months earlier than the controls.[12] Although leaf clipping in early October produced more inflorescences, seed set did not differ from unclipped plants.[12] This was thought to be because many clipped plants had flowered earlier (in winter), when pollinators were not as active.[12]

X. preissii showed a strong capacity to recover from leaf clipping, even after clipping every month for 16 months.[152] However, starch reserves were depleted in the desmium of clipped plants, and at one of two study sites even a single clipping was sufficient to reduce starch reserves.[152] The impact of regular foliage clipping over periods greater than 16 months is unknown. However in Western Australia, *X. preissii* were killed by Port Lincoln parrots *Barnardius zonarius semitorquatus* through repeated browsing (clipping and shredding) of the leaves.[147] It is unclear whether these deaths were caused only by clipping or by a combination of clipping and leaf chaff accumulating and rotting on top of the plant following parrot feeding. For more detail on Port Lincoln parrot damage to *Xanthorrhoea* see section **4.8.1** of this report. Further information on the impact of foliage harvest is in sections **2.8.0** and **3.8.0** of this report, especially Figures 3 and 5.

4.7.1.2 Impact on environment

Harvesting of whole *Xanthorrhoea* plants or parts thereof may impact on associated animals. Tables 7 and 8 summarise all animals currently known to utilize *Xanthorrhoea* species. In most cases the importance of this utilization to either the *Xanthorrhoea* or the animal is unknown.

Table 8 lists a diverse range of over 315 invertebrate species known to utilize *Xanthorrhoea* across Australia. The list includes beetles, native bees, moths, butterflies, spiders, bugs, cockroaches, ants, scale insects, nematodes, flies, grasshoppers, termites and katydids. Invertebrate use of *Xanthorrhoea* is poorly known, and it can be expected other taxa apart from those listed in Table 8 will use *Xanthorrhoea*. These might include pollen-feeding springtails (Collembola), pollen- and nectar-feeding stoneflies (Plecoptera), thrips (Thysanoptera) and caddis-flies (Tricoptera). Many more spiders than those listed can be expected to use *Xanthorrhoea* for feeding, shelter and/or breeding sites.

There is still much to learn of the importance of the relationship between *Xanthorrhoea* and associated invertebrates. Some of these associations may not be beneficial to *Xanthorrhoea*. For instance, it is already known that the larvae of the moth *Meyriccia latro* can destroy entire seed sets on individual plants,[90,152,155] or stunt or twist inflorescences.[241] Other associated invertebrates may not be harmful to *Xanthorrhoea*. The crowns of *Xanthorrhoea* species are considered some of the only refuge habitat for invertebrates after severe fires.[90] Evidence for this comes from Western Australia where the crowns of freshly burnt *X. preissii* were found to be used by at least nine invertebrates species that have not been recorded on unburnt plants.[310] Unpublished data for insects taking refuge in the burnt crowns of *X. resinifera* in New South Wales also suggests *Xanthorrhoea* are an important insect refuge immediately post-fire.[305,313] *Xanthorrhoea* could also be important to threatened invertebrate species. An *Anonychomyrma* ant species that sometimes use *Xanthorrhoea* as a nest site,[120] is a symbiotic attendant ant to the larvae of the endangered bulloak jewel butterfly *Hypochrysops piceatus*.[123] Loss of *Xanthorrhoea* could have a serious impact on the breeding success of some invertebrates. *Xylocopa aeratus* and a number of other native carpenter bees tunnel into old *Xanthorrhoea* flower scapes, using the tunnels as breeding and/or refuge sites.[55,89,92,93,124,291,307] The greatest threat to these carpenter bees is habitat destruction and loss of nesting sites.[291] It is already believed that extensive clearing for agriculture and property development is a probable cause behind the dramatic decline in the distribution of bees in the genus *Xylocopa*.[307] *Xylocopa aeratus* is already reported to be extinct on mainland South Australia.[319] However, the impact on carpenter bees from the clearing or harvesting of *Xanthorrhoea* or its flower scapes has still not been investigated. See additional comments on invertebrates using *Xanthorrhoea* in sections **2.5.4** and **3.5.4** of this report.

Table 9 lists nearly 100 vertebrate species that use *Xanthorrhoea*, and includes at least 60 bird species. *Xanthorrhoea* seeds are part of the diet of two parrots listed as vulnerable[1] in Queensland, the pink cockatoo *Cacatua galerita* and the ground parrot *Pezopurus wallicus*. Ground parrots are reported to move into fire-prone heathland in south-eastern Australia within a year of a fire when sedges seed prolifically and plants such as *X. resinifera* have a peak in seed production.[139] The ground parrot is also recorded nesting on the ground under the “down-turned leaves” of a xanthorrhoea.[35] Except for unidentified rodents gnawing off *X. fulva* scapes and feeding from the seeds of fallen scapes,[102] no other published information was found on *Xanthorrhoea* in the diet of rodents. Most rodents are primarily seed feeders,[52] so it would be surprising if only a few of the over 50 extant native rodent species in Australia[53] did not include *Xanthorrhoea* seeds in their diet when the opportunity arose. Rodents are known to visit blossoms outside Australia,[95] but records of Australian rodents feeding on blossoms are scant. The Australian southern bushrat *Rattus fuscipes* has been observed visiting blossoms, [95] but it is not known if this and other Australian rodent species visit *Xanthorrhoea* flowers. However, the unknown rodents recorded feeding on *X. fulva* seed,[102] were suspected of being *R. fuscipes* based on gnaw marks and a knowledge of rodent species known to occur where this feeding was observed.[301] A *Rattus fuscipes* has also been found nesting on the ground under the leaf skirt of a *Xanthorrhoea*.[301] The endangered[183] South Australian heath rat *Pseudomys shortridgei* is reported to use *Xanthorrhoea* foliage as a refuge site.[211]

The squirrel glider *Petaurus norfolcensis* has been recorded feeding on the flowers/nectar of *Xanthorrhoea* species,[50,51] the plants are suspected of being a valuable food resource to the glider.[99] This glider might also feed on edible exudate from the flower stalks (scapes).[51] Currently the glider is listed as endangered in South Australia,[183] and vulnerable in Victoria and New South Wales.[181,257] The sugar glider *P. breviceps* is also recorded on the flower spikes of *Xanthorrhoea*,[171] and has been noted feeding on the nectar.[8] This glider is currently listed as rare in South Australia.[183] The eastern pygmy possum *Cercartetus nanus*, which is listed as vulnerable in South Australia and New South Wales,[181,183] will also nest in *Xanthorrhoea*.[254] Feathertail gliders *Acrobates pygmaeus* are recorded feeding and nesting in *Xanthorrhoea*,[252] and are listed as endangered in South Australia.[183] The Queensland blossom bat *Syconycteris australis* has been observed feeding on flowering *Xanthorrhoea* in northeast New South Wales.[76] It has also been mist-netted around flowering *Xanthorrhoea* in State-owned pine plantations in south-east Queensland.[77] The nectar-feeding dibbler *Parantechinus apicalis*, a threatened small marsupial from Western Australia, is reported to nest in either dead leaves or dead trunks of grasstrees.[78] The endangered[183] red-tailed phascogale *Phascogale calura* and Kangaroo Island dunnart *Sminthopsis aitkeni* both use *Xanthorrhoea* as nest/refuge sites.[83] The white-footed dunnart, which is listed as rare in Queensland,[4] is recorded using both dead and live *Xanthorrhoea* as shelter and nest sites.[256] The dunnart *S. murina* also nests in *Xanthorrhoea*,[211] this dunnart listed as rare in Victoria.[257]

Research in the Brisbane Ranges of Victoria found the number of brown antechinus *Antechinus stuartii* trapped dropped significantly following a major change in understorey structure, composition and cover through loss of *X. australis* by *Phytophthora cinnamomi* dieback.[187] *Antechinus stuartii* in the Brisbane Ranges frequently made nests at ground level in large *X. australis*.[188] A drop in the Brisbane Range *A. stuartii* numbers was thought to be related to either a loss of shelter sites in the dead skirts of the grasstrees, a loss of *X. australis* ground cover or a reduction in insect abundance caused by vegetational changes.[187] In heathland north of Sydney, *X. media* nectar was found to be an important post-fire food resource for *A. stuartii* that survived a fire.[287]

For the vulnerable[292,314] southern brown bandicoot *Isoodon obesulus* in the south-east of South Australia, *X. australis* provided important nest sites where plants had a well developed skirt of dead and live foliage that reached the ground.[292,335] These nest sites were beneath the foliage of *X. australis* with trunks 35–75cm tall.[335] The nest sites were well camouflaged and thought to provide protection from predators.[335] *Isoodon obesulus* also occurs on Cape York Peninsula in Queensland,[292] but it is not known if there are *Xanthorrhoea* present where this bandicoot occurs on Cape York Peninsula. *Xanthorrhoea* could be important refuge sites for other bandicoot species in eastern Queensland, but this requires further investigation.

See addition comments on vertebrates using *Xanthorrhoea* in sections see **2.5.4** and **3.5.4** of this report. Section **2.5.4** comments on the importance of *X. johnsonii* to the endangered mahogany glider *Petaurus gracilis*.

Table 10 lists over 40 fungi recorded on *Xanthorrhoea* species. The most significant of these is the root rot/dieback fungus *Phytophthora cinnamomi*. This fungus can cause severe dieback in a number of *Xanthorrhoea* species. For more information on the impact of the fungus see section **4.8.3** of this report.

Table 8: Invertebrates utilizing *Xanthorrhoea* species. * = introduced species; N = not listed as rare or threatened in Queensland (among these will be species that don't occur in Queensland or their occurrence in Queensland is unknown).

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Acantholophus echinatus	weevil	Beetle	N	*X. resinifera*	In foliage	305
Acantholophus marshami	weevil	Beetle	N	*Xanthorrhoea* sp. *Xanthorrhoea* spp. (incl. *X. media* & *X. arborea*)	Adults gnaw pieces from leaves. Larvae in crowns. Larvae feed on the bases of living leaves at the top of the trunk.	55 163 164
Acantholophus scabrosus	weevil	Beetle	N	*X. resinifera*	In foliage	305
Acrididae (species unknown_eastern Australia)	-	Grasshopper	N	*X. resinifera*	In foliage	305
Acrodontia sp.	-	Cricket	N	*X. resinifera*	In foliage	305
Allodape bribiensis (jun. syn. *Ceratina australensis*)	native bee	Bee	N	*Xanthorrhoea* sp.	Nest in dead flower stems	89
Adelium geniale	-	Beetle	N	*X. resinifera*	In foliage	305
Adelium sp.		Beetle	N	*X. resinifera* *X. preissii*	In foliage. On recently burnt plants.	305 310
Aethyssius viridis	alleculid beetle	Beetle	N	*X. johnsonii*	Adults resting on outer leaves	3
Agarista agricola	Joseph's coat moth	Moth	N	*Xanthorrhoea* sp.	On flowers	120
Agrilus sp.	jewel beetle	Beetle	N	*X. resinifera*	In foliage	305
Agrotis infusa	bogong moth	Moth	N	*X. glauca* subsp. *angustifolia* *X. australis*	On flowering spikes. On flowers.	171 283
Agrypnus sp.	click beetle	Beetle	N	*X. resinifera*	In foliage	305
Agrypnus sp. A	click beetle	Beetle	N	*X. resinifera*	In foliage	305
Agrypnus sp. B	click beetle	Beetle	N	*X. resinifera*	In foliage	305
Amegilla rhodoscymna	-	Bee	N	*Xanthorrhoea* sp.	On plant	124
Amphylaeus morosus		Bee	N	*Xanthorrhoea* sp.	Nest inside dead flower stems & adults feed on flowers. Nest in plant.	89 124
Amphylaeus obscuriceps	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Amphylaeus nubilosellus	-	Bee	N	*Xanthorrhoea* sp.	Nest in plants	124
Anaxo cylindricus	-	Beetle	N	*Xanthorrhoea* spp.	Pest on plant	144
Anisolabida (species unknown)	-	Earwig	N	*X. resinifera*	In foliage	305
Anonychomyrma sp. (*itinerans* species group)	-	Ant	N	*Xanthorrhoea* sp.	Nest on plant	120
Aoplocnemus sp.	weevil	Beetle	N	*X. resinifera*	In foliage	305
Aoplocnemus sp. A	weevil	Beetle	N	*X. resinifera*	In foliage	305
Aphanocorynus rugosipennis (jun. syn. Notiosomus rugosipennis and *Tranes rugosipennis*)	cossinine weevil	Beetle	N	*X. australis* *Xanthorrhoea* sp. (Beerwah, Qld)	Feeds in flower stalk. Tunnels in flower stalks.	38 145, 148
Aphileus lucanoides	click beetle	Beetle	N	*Xanthorrhoea* sp.	Adults hide between leaves	27
*Apis mellifera**	honey bee	Bee	N	*X. johnsonii*	Adults feed on pollen and nectar	90
Araneae (species unknown)	-	Spiders	N	*Xanthorrhoea* spp.	Refuge in new green growth during fire	306
Asceparnodes duplicatus	weevil	Beetle	N	*X. resinifera*	In foliage	305
Ascesis australis	-	Beetle	N	*X. johnsonii*	Adult resting on or amongst leaves	3
Aspidiotus nerii (jun. syn. *Aspidiotus hederae*)	-	Scale insect	N	*Xanthorrhoea* spp.	Pest on plant	144
Athemistus sp.	longicorn beetle	Beetle	N	*X. resinifera*	In foliage	305
Bardistus cibarius	longicorn beetle	Beetle	N	*Xanthorrhoea* spp.	Larvae in stems. Pest on plant.	125 144
Blattidae (possibly *Robshelfordia* species)	-	Cockroach	N	*X. resinifera*	In foliage	305
Blattidae (unknown species)	-	Cockroach	N	*X. resinifera* *Xanthorrhoea* spp.	In foliage. Refuge in new green growth during fire.	305 306
Blattidae (unknown species 1_Western Australia)	-	Cockroach	N	*X. preissii*	On freshly burnt plants.	310

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Blattidae (unknown species 2_Western Australia)	-	Cockroach	N	*X. preissii*	On freshly burnt and unburnt plants	310
Brachycaulus klugi	-	Beetle	N	*X. johnsonii*	Adult resting on outer leaves	3
Braunsapis praesumptiosa	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Braunsapis simillima	-	Bee	N	*Xanthorrhoea* sp.	Nest in flower stems	89
Braunsapis unicolor	-	Bee	N	*Xanthorrhoea* sp.	Nest in flower stems	89
Callipappus spp.	-	Scale insect	N	*Xanthorrhoea* spp.	Pests on plant	144
Calliphora sternalis	blow-fly	Fly	N	*X. australis*	On flowers	283
Calliphora stygia	blow-fly	Fly	N	*X. australis*	On flowers	283
Calliphora australica	blow-fly	Fly	N	*X. australis*	On flowers	283
Callomelitta antipodes	-	Bee	N	*X. caespitosa*	On plant	297
Campolene nitida	-	Beetle	N	*X. resinifera*	In foliage	305
Catasphactes sp.	assassin bug	Bug	N	*X. resinifera*	In foliage	305
Cerambycidae (species unknown)	-	Beetle	N	*X. resinifera*	In foliage	305
Cerambycidae (species unknown)	longicorn beetle	Beetle	No	*Xanthorrhoea* spp.	Larvae bore amongst hard leaf bases of dead plants	250
Chalcolampra sp.	-	Beetle	N	*X. resinifera*	In foliage	305
Chalicodoma fultoni	resin bee	Bee	N	*Xanthorrhoea* sp.	On flowers	124, 258
Chalicodoma semiluctuosa	resin bee	Bee	N	*Xanthorrhoea* sp.	On plant On flowers	124 258
Chalicodoma silvestris	resin bee	Bee	No	*Xanthorrhoea* sp.	Female in dead flower stem	89
Chauliognathus nobilitatus	cantharid beetle	Beetle	N	*X. resinifera*	In foliage	305
Chilopoda (species unknown)	-	Centipede	N	*Xanthorrhoea* spp.	In dead plants	250
Chionaspis eugeniae	-	Scale insect	N	*Xanthorrhoea* sp.	On leaves	55
Chloropidae (3 species)	-	Flies	N	*X. australis*	On flowers	283
Cisseis duodecimmaculata	12 spot jewel beetle	Beetle	N	*Xanthorrhoea* sp. (Beerwah, Qld.) *Xanthorrhoea* sp. (Sydney area)	On leaves. Feed on leaves.	145 55
Cleptor inermis	-	Beetle	N	*X. johnsonii*	Adult resting on leaves	3
Coccinellidae (possibly *Scymnus* species).	-	Beetle	N	*X. resinifera*	In foliage	305
Coenosia sp.	-	Fly	N	*X. australis*	On flowers	283
Coleoptera (species unknown, possibly *Adelium capitulum*)	-	Beetle	N	*X. resinifera*	In foliage	305
Coleoptera (species unknown)	chafer or scarab beetle	Beetle	N	*Xanthorrhoea* spp.	Larvae in decaying stems	250
Coleoptera (species unknown)	-	Beetle		*Xanthorrhoea* spp.	Feeding on nectar	250
Comptosia decedens	-	Bee fly	N	*Xanthorrhoea* sp.	Visiting flowers	273
Comocrus behri	mistletoe day-flying moth	Moth	N	*Xanthorrhoea* sp.	On flowers Feed on nectar	120 145
Comodica acontistes	-	Moth	N	*Xanthorrhoea* sp.	Larvae in flower stems	88, 121, 130
Conoderus sp.	click beetle	Beetle	N	*X. resinifera*	In foliage	305
Conoderus sp. 1	click beetle	Beetle	N	*X. johnsonii*	Adult mating & resting sites	3
Conoderus sp. 2	click beetle	Beetle	N	*X. johnsonii*	Adult mating & resting sites	3
Coptotermes sp.	-	Termite	N	*X. australis*	On trunk	283
Coranus callosus	assassin bug	Bug	N	*X. resinifera*	In foliage	305
Coranus sp.	assassin bug	Bug	N	*X. resinifera*	In foliage	305
Cossodes lyonetii (jun. syn. *Tirema lyonetii*)	wood moth	Moth	N	*Xanthorrhoea* sp.	Larvae feed on roots	94
Criconema lanifrons	-	Nematode	N	*X. s. tateana*	Pathogen	173
Criconema pasticum	-	Nematode	N	*X. semiplana* *X. semiplana* subsp. *tateana*	Pathogen Pathogen	173 173
Cruria donovani	day-flying moth	Moth	N	*Xanthorrhoea* sp.	On flowers	120
Cruria synopla	day-flying moth	Moth	N	*Xanthorrhoea* sp.	On flowers	120
Cryphodera sp.	-	Nematode	-	*X. semiplana* *Xanthorrhoea* spp.	Pathogen. Pest on plant.	172 144
Cryptobarsac rubriops	leaf hopper	Bug	N	*X. preissii*	On plant. In skirt of dead leaves on trunk.	124 255

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Cryptocephalus argentatus	leaf beetle	Beetle	N	*X. johnsonii*	Adults mating on leaf	3
Cryptocephalus dichrous	chrysomelid beetle	Beetle	N	*X. johnsonii*	Adults resting on outer leaf	3
Cryptops sp.	-	Centipede	N	*X. preissii*	On freshly burnt plants	310
Ctenidae (species unknown)	-	Spider	N	*X. resinifera*	In foliage	305
Curculionidae (species unknown_eastern Australia)	weevil	Beetle	N	*X. johnsonii* *X. resinifera*	Borer in cordex In foliage	158 305
Danaus chrysippus petilia	lesser wanderer	Butterfly	N	*X. johnsonii*	Adults feeding on nectar	158
Danaus plexippus	wanderer	Butterfly	N	*X. johnsonii*	Adults feeding on nectar	158
Delias argenthona	scarlet jezebel	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar	120 145
Demetrida longicollis	-	Beetle	N	*X. resinifera*	In foliage	305
Demetrida sp.	-	Beetle	N	*Xanthorrhoea* spp.	Pest on plant. On plant.	144 305
Demetrida sp. A	-	Beetle	N	*X. resinifera*	In foliage	305
Demetrida sp. B	-	Beetle	N	*X. resinifera*	In foliage	305
Demetrida vittata	-	Beetle	N	*X. resinifera*	In foliage	305
Depsages solandri	longicorn beetle	Beetle	N	*X. johnsonii* *Xanthorrhoea* sp. *Xanthorrhoea* spp.	Adults feed on bases of young leaves. Eggs laid in flower stalk. Larvae burrow into and feed on the flower stalk pith. Larvae prune off flower stalks. Pupate at base of flower stalk. Host plant associated with flower stalk.	3 27 87, 27 145 87 174
Dictyotus caenosus	shield bug	Bug	N	*X. resinifera*	In foliage	305
Dictyotus sp.	-	Bug	N	*X. resinifera*	In foliage	305
Diplocoelus xanthorrhoae	-	Beetle	N	*X. johnsonii*	Adults amongst leaves	3
Diplopoda	-	Millipedes	N	*Xanthorrhoea* spp.	In dead plants	250
Diplopoda (species unknown_eastern Australia)	-	Millipede	N	*X. resinifera*	In foliage	305
Dolichoderus doriae	-	Ant	N	*Xanthorrhoea* sp.	Nest in dead grasstrees	55
Scaptomyza australia	-	Fly	N	*X. australis*	On flowers	283
Dysmicoccus saustralis	-	Mealy bug	N	*X. quadrangulata* *Xanthorrhoea* spp.	Collected from leaf bases. Pest on plant.	106 144
Dysmicoccus waustensis	-	Mealy bug	N	*X. preissii* *Xanthorrhoea* sp.	Collected from leaf bases. Pest on plant.	106 144
Dysmicoccus xanthorrhoeae	-	Mealy bug	N	*Xanthorrhoea* spp.	Pest on plant	144
Enneaphyllus aeneipennis	cerambycid beetle	Beetle	N	*Xanthorrhoea* sp.	Host plant	174
Ensifera (species unknown)	-	Cricket	N	*Xanthorrhoea* spp.	Found amongst the leaves of the central region of the apical meristem and feeding young leaf shoots	328
Euploea core corinna	common crow	Butterfly	N	*X. johnsonii*	Adults on flowers	158
Euhesma xana	-	Bee	N	*Xanthorrhoea* sp. (Hope Vale Mission north Queensland)	On flowers	225
Ephippium albitarsis	-	Fly	N	*Xanthorrhoea* sp.	Larvae and pupae in decaying caudex	55
Episcaphula australis	-	Beetle	N	*X. resinifera*	In foliage	305
Erythraeida (species unknown_eastern Australia)	-	Spider	N	*X. resinifera*	In foliage	305
Euryglossina sp.	-	Bee	N	*Xanthorrhoea* sp.	From tunnel in flower stalk	124
Eurymblope rubrovitatta	-	Bug	N	*Xanthorrhoea* spp.	Pest on plant	144
Eutrichopidia latinus	-	Moth	N	*Xanthorrhoea* sp.	On flowers	120
Exoneura albopilosa	-	Bee	N	*Xanthorrhoea* sp.	Nest in flower stems	89
Exoneura angophorae	-	Bee	N	*Xanthorrhoea* sp.	Nest in dead flower stems	89
Exoneura asimillima	-	Bee	N	*Xanthorrhoea* sp.	Nest in dead flower stems	89

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Exoneura aterrima	-	Bee	N	*Xanthorrhoea* sp.	Nest in dead flower stems	89
Exoneura bicolor	-	Bee	N	*Xanthorrhoea* sp. *Xanthorrhoea* spp.	Tunnel in flower stem. Pest on plant.	124 144
Exoneura hamulata	-	Bee	N	*Xanthorrhoea* sp.	Nest in dead flower stems	89
Exoneura illustris	-	Bee	N	*Xanthorrhoea* sp.	Nest in dead flower stems	89
Exoneura pictifrons	-	Bee	N	*Xanthorrhoea* sp. *X. preissii*	Nest in dead flower stems. On flowers. On flower spike. On plant. On flowers.	89 258 124 124 258
Exoneura ploratula	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89, 91
Exoneura sp.	-	Bee	N	*Xanthorrhoea* sp.	On flowers On flower spike	124, 258 124
Figulus regularis	stag beetle	Beetle	N	*X. johnsonii*	Adults in central core of a dead, burnt trunk, also adults & larvae in decaying cortical tissue of a dead trunk.	170
Formicidae (unknown species)	-	Ant	N	*Xanthorrhoea* sp. *Xanthorrhoea* spp.	Nesting in old *Xylocopa aeratus* nest in dead flower stem. Feeding on nectar. Feeding on nectar.	93 211 250
Formicidae (Unknown ant species [*Rhytidoponera victorie* and/or *R. tasmaniensis*, *Monomorium* (*Chelaner*) kiliani group, *Pheidole* sp. A., *Pheidole* sp. B, *Monomorium* (*Chelaner*). *flavigaster* group, *Monomorium* (*Chelaner*) cf. *leave* group, *Monomorium* sp. A. *Pheidole* sp. C]).	-	Ant	N	*X. australis*	Seed removal from ground	188
Gnaphosidae (species unknown_eastern Australia)	-	Spider	N	*X. resinifera*	In foliage	305
Graphium sarpedon choredon	blue triangle	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar.	120 145
Gryllidae (species unknown_eastern Australia)	-	Cricket	N	*X. resinifera*	In foliage	305
Harmonia conformis	ladybird beetle	Beetle	N	*X. johnsonii*	Adult among young leaves	3
Hecatesia fenestrata	whistling moth	Moth	N	*Xanthorrhoea* sp.	On flowers	120
Helicotylenchus exallus	-	Nematode	N	*X. s. tateana*	Pathogen	173
Helicotylenchus sp.	-	Nematode	N	*X. quadrangulata* *Xanthorrhoea* spp.	Pathogen. Pests on plant.	172 144
Helina sp.	-	Fly	N	*X. australis*	On flowers	283
Hemicloea sp.	-	Spider	N	*X. resinifera*	In foliage	305
Hemicriconemoides insignis	ring nematode	Nematode	N	*Xanthorrhoea* spp. *X. semiplana* *X. semiplana* subsp. *tateana*	Pests on plant. Pathogen. Pathogen. Pathogen.	144 172 173 173
Hemicycliophora arenaria	sheath nematode	Nematode	N	*X. quadrangulata* *Xanthorrhoea* spp.	Pathogen. Pests on plant.	172, 173 144
Hemicycliophora natalensis	sheath nematode	Nematode	N	*X. semiplana* *X. semiplana* subsp. *tateana* *Xanthorrhoea* spp.	Pathogen. Pathogen. Pests on plant.	172, 173 173 144
Hemicycliophora truncata	sheath nematode	Nematode	N	*X. quadrangulata* *X. semiplana* *Xanthorrhoea* spp.	Pathogen. Pathogen. Pests on plant.	172, 173 173 144
Hemisaga denticulata	-	Katydid	N	*Xanthorrhoea* sp.	Feed on *Kawanaphila* sp. katydids feeding on flowers	128
Hemithynnus sp.	-	Wingless wasp	N	*X. australis*	On flowers	283
Hesperilla crypsigramma	wide-brand sedge-skipper	Butterfly	N	*Xanthorrhoea* sp. (Toowoomba area)	On flowers	120

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Hesperilla malindeva	two-spotted sedge-skipper	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar.	120 145
Hesperilla sarnia	swift sedge-skipper	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar.	120 145
Hesthesis cingulata	wasp beetle	Beetle	N	*Xanthorrhoea* spp.	Pest on plant	144
Heterapoides extensa	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Heterapoides halictiformis	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89, 91
Heteronympha merope	common brown	Butterfly	N	*Xanthorrhoea* sp.	Adult feeds on nectar	49, 85
Heteropodid (species unknown)	-	Spider	N	*X. resinifera*	In foliage	305
Heterotermes infrequens	-	Termite	N	*X. preissii*	On plant	124
Hololepta sidnensis	-	Beetle	N	*X. johnsonii*	Adult amongst young leaves. Adults in top of decaying caudex or between it & outer sheath.	3 55
Holoplatys sp.	-	Spider	N	*X. resinifera*	In foliage	305
Homalictus blackburni	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Homolictus bremerensis	-	Bee	N	*Xanthorrhoea* sp.	On flowers	124, 258
Homalictus cassiaeflorisi	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Homalictus dampieri	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Homalictus murrayi	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Homalictus niveifrons	-	Bee	N	*X. caespitosa*	On plant	297
Homolictus sp.	-	Bee	N	*Xanthorrhoea* sp.	On flowers	124, 258
Homalictus sphecodopsis	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Howeotranes sp. (jun. syn. *Tranes*)	weevil	Beetle	N	*Xanthorrhoea* sp. *Xanthorrhoea* spp.	Adults at base of flower stem and among young leaves. Associated with flower stalks. Pest on plant.	55 126 144
Hybrenia subsulcata	-	Beetle	N	*Xanthorrhoea* sp.	Larvae in decaying caudex, adults amongst leaves,	55
Hylaeus alcyoneus	masked bee	Bee	N	*Xanthorrhoea* sp.	On flowers	124, 258
Hylaeus albonitens	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus amatus	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus amiculiformis	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89, 91
Hylaeus amiculinus	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus bituberculatus	masked bee	Bee	N	*X. caespitosa* *X. semiplana* subsp. *tateana*	On plant. On plant.	297 297
Hylaeus ceniberus	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus disjunctus	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus lateralis	masked bee	Bee	N	*Xanthorrhoea* sp.	On plant	124
Hylaeus quadratus	masked bee	Bee	N	*X. preissii*	On flower spike	124, 258
Hylaeus nubilosus	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89, 91
Hylaeus rotundiceps	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus ruficeps ruficeps	masked bee	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Hylaeus sp.	masked bee	Bee	N	*Xanthorrhoea* sp.	On flowers	124, 258
Hymenoptera (unknown thynnine wasp species)	-	Wasp	N	*X. preissii*	Visiting flowers	273
Hypogomphus sp.	shield bug	Bug	N	*X. resinifera*	In foliage	305
Iridomyrmex gracilis	-	Ant	N	*Xanthorrhoea* sp.	Nest in dead flower stalks	55

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Iridomyrmex sp.	-	Ant	N	*X. johnsonii* *X. preissii*	On flowering spike. On plant.	158 310
Isoptera (species unknown)	-	Termite	N	*X. preissii* *Xanthorrhoea* sp.	Termite mud encasing trunks. Feeding on dead leaves on trunk. Termite invasion	101 152 348
Kawanaphila goolwa	-	Katydid	N	*Xanthorrhoea* sp.	Feed on flowers	128
Kawanaphila nartee	-	Katydid	N	*Xanthorrhoea* sp.	Adults feed on nectar and pollen	128
Lactura spp.	-	Moth	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar.	120 145
Lasioglossum ebeneum	-	Bee	N	*Xanthorrhoea* sp.	Visiting flowers	273
Lasioglossum flavopunctatum	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Lasioglossum lanarium	-	Bee	N	*X. caespitosa*	On plant	297
Lasioglossum occidens	-	Bee	N	*Xanthorrhoea* sp.	On flowers	124, 258
Lasioglossum seductum	-	Bee	N	*X. semiplana* subsp. *tateana*	On plant	297
*Lasioglossum sp. (*subgenus *Parasphecodes)*	-	Bee	N	*X. semiplana* subsp. *tateana*	On plant	297
Lasioglossums sp	-	Bee	N	*Xanthorrhoea* sp.	On plant	124, 258
Laxta granicollis	-	Cockroach	N	*X. resinifera*	In foliage	305
Leioproctus sp.	-	Bee	N	*Xanthorrhoea* sp. *X. preissii*	On plant. On flowers. On flower spike.	124 124, 258 124
Leioproctus sp. M253?	-	Bee	N	*Xanthorrhoea* sp.	On flowers	258
Leioproctus sp. M369	-	Bee	N	*X. preissii*	On flowers	258
Leioproctus cupreus	-	Bee	N	*X. caespitosa*	On plant	297
Leioproctus tuberculatus	-	Bee	N	*X. semiplana tateana*	On plant	297
Lenophila achilles	-	Fly	N	*Xanthorrhoea* spp.	Pest on plant	144
Lenophila coerulea	-	Fly	N	*Xanthorrhoea* spp.	Pest on plant	144
Lenophila danielsi	-	Fly	N	*Xanthorrhoea* spp.	Pest on plant	144
Lenophila nila	-	Fly	N	*Xanthorrhoea* spp.	Pest on plant	144
Lenophila secta	-	Fly	N	*Xanthorrhoea* spp.	Pest on plant	144
Lenophila (3 spp.)	-	Fly	N	*Xanthorrhoea* sp.	Larvae in trunks	122
Lenophila (5 spp.)	-	Fly	N	*Xanthorrhoea* sp.	On leaves	122
Lepidoptera (species unknown)	-	Butterfly	N	*Xanthorrhoea* sp.	Feeding on nectar	210
Lilioceris bakewelli (Crioceris fuscomaculata in cited reference*)*	-	Beetle	N	*X. johnsonii*	Adults usually amongst young leaves	3
Lindingaspis neorossi	-	Scale insect	N	*Xanthorrhoea* spp.	On plants	316
Lindingaspis rossi (jun. syn. *Aspidiotus rossi*)	-	Scale insect	N	*Xanthorrhoea* sp.	On leaves. On plant	55 316
Longidorus taniwha	-	Nematode	N	*Xanthorrhoea* spp.	Pests on plant	144
Lychas marmoreus	-	Scorpion	N	*X. resinifera*	In foliage	305
Lycidae (species unknown_Western Australia)	-	Beetle	N	*X. preissii*	On unburnt and freshly burnt plants	310
Lycidas sp.	-	Spider	N	*X. resinifera*	In foliage	305
Lycosa serrata?	wolf spider	Spider	N	*X. preissii*	On plant recently burnt	310
Mantidae (possibly *Pseudomantis* species).	-	Praying mantis	N	*X. resinifera*	Nymph, in foliage	305
Margarodidae (species unknown_Western Australia)	-	Scale insect	N	*X. preissii*	Infest growing root tips	152, 241
Melangyna collatus	syrphid fly	Fly	N	*X. australis*	On flowers	283
Melanitis leda bankia	evening brown	Butterfly	N	*X. johnsonii*	Adults on flowers	158
Melobasis cuprifera	jewel beetle	Beetle	N	*X. johnsonii*	Adult resting on outer mature leaves	3
Meroglossa impressifrons impressifrons	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Meroglossa striaticeps	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Meroglossa sulcifrons	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Metistete sp.	-	Beetle	N	*X. resinifera*	In foliage	305
Metriorrhynchus sp.	-	Beetle)	N	*X. australis*	On flowers	283
Meyriccia latro (jun. syn*. Hylaletis) latro*) (continued next page)	-	Moth	N	*Xanthorrhoea* sp.	Larvae & pupae on scape of flower stalks. Pupae among old leaf bases near ground. Larvae bore in flower stalk. On plant.	33, 55 88 145, 148 316

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Meyriccia latro (continued)	-	Moth	No	*Xanthorrhoea* spp. *X. johnsonii* *X. australis* *X. preissii*	Larvae tunnel in flower spikes. Pest on plant. Larvae predator of inflorescences. Larvae bore in flower spike and damage developing seeds. Young larvae inside fruits, older larvae in spikes. On flower scape. Seed predation by larvae. In flower spikes. In inflorescence. Larvae predate flower spikes/seeds	127, 130 144 290 90 116 283 98 38 341 152
Micropecila breweri	-	Beetle	N	*Xanthorrhoea* sp.	Larvae in decaying caudex	55
Microporopterus curvirostris	weevil	Beetle	N	*X. resinifera*	In foliage	305
Miturgidae (species unknown_eastern Australia)	-	Spider	N	*X. resinifera*	In foliage	305
Moerarchis australasiella	-	Moth	N	*Xanthorrhoea* sp. *Xanthorrhoea* spp.	Larvae in dead trunks. Pest on plant.	88 144
Moerarchis sp.	-	Moth	N	*Xanthorrhoea* spp.	Pest on plant	144
Moerarchis spp.	-	Moth	N	*Xanthorrhoea* spp.	Dead trunks	127
Morulaimus arenicolus	-	Nematode	N	*X. semiplana* *Xanthorrhoea* spp.	Pathogen. Pests on plant.	172 144
Morulaimus whitei	-	Nematode	N	*X. semiplana* *X. semiplana* subsp. *tateana* *Xanthorrhoea* spp.	Pathogen. Pathogen. Pests on plant.	172, 173 173 144
Myrmecia simillima	bull ant	Ant	N	*X. resinifera*	In foliage	305
Myrmecia sp.	bull ant	Ant	N	*X. johnsonii*	On flowering spike	158
Nabis sp.	-	Bug	N	*X. resinifera*	In foliage	305
Neohesperilla xanthomera	yellow grass-skipper	Butterfly	N	*Xanthorrhoea* sp.	On flowers	120
Nomioides perditellus	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Nomia flavoviridis	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Nomia tomentifera	-	Bee	N	*Xanthorrhoea* sp.	On plants	124
Nyllius australicus	assassin bug	Bug	N	*X. resinifera*	In foliage	305
*Octotoma scabripennis**	lantana beetle	Beetle	N	*X. johnsonii*	Adults among young leaves (over wintering site?)	3
Ogyris genoveva duaringa	genoveva azure	Butterfly	N	*Xanthorrhoea* sp.	Feed on nectar	145
Ogyris zosine zosine	northern purple azure	Butterfly	N	*Xanthorrhoea* sp.	On flowers	120
Oncodosia ampla	-	Bee	N	*Xanthorrhoea* sp.	Visiting flowers	273
Opisthonocus sp.	jumping spider	Spider	N	*X. resinifera*	In foliage	305
Orthoprosopa nigra	-	Fly	N	*Xanthorrhoea* sp.	Larvae in decaying caudex	55
Orthoprosopa sp.	-	Fly	N	*Xanthorrhoea* sp.	Larvae in decaying caudex	55
Oxydema major (jun. syn. *Notiosomus xanthorrhoeae* and *Tranes xanthorrhoeae*)	weevil	Beetle	N	*X. johnsonii* *Xanthorrhoea* sp.	Adult amongst young leaves. Adults attack green leaves at their base.	3 27
Oxydema sp. (jun. syn. *Notiosomus* and *Tranes*)	weevil	Beetle	N	*X. resinifera*	In foliage	305
Oxyops reticulata	weevil	Beetle	N	*X. resinifera*	In foliage	305
Pachysaga australis	-	Katydid	N	*X. preissii*	Resting in axils of young, ground-level plants	128
Palaeorhiza longiceps	-	Bee	N	*Xanthorrhoea* sp.	Adults feed on flowers	89
Paracardiophorus sp.	-	Beetle	N	*X. resinifera*	In foliage	305
Paralongidorus eucalypti	-	Nematode	N	*X. semiplana* subsp. *tateana*	Pathogen	173
Paralongidorus sp.	needle nematode	Nematode	N	*X. semiplana* *Xanthorrhoea* spp.	Pathogen. Pest on plant.	172 144
Paropsis ornata	-	Beetle	N	*X. johnsonii*	Adult resting on outer leaves	3

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Paropsis sp.	-	Beetle	N	*X. johnsonii* *X. preissii*	Adult on outer leaves. On plant.	3 310
Paropsis trifasciata	-	Beetle	N	*X. johnsonii*	Adult resting on outer leaves	3
Peleorhinus caudatus	weevil	Beetle	N	*X. resinifera*	In foliage	305
Pentatomidae (species unknown_eastern Australia)	-	Bug	N	*X. resinifera*	In foliage	305
Perperus lateralis	weevil	Beetle	N	*X. resinifera*	In foliage	305
Perperus sp.	weevil	Beetle	N	*X. resinifera*	In foliage	305
Phalaenoides glycinae	grapevine moth	Moth	N	*Xanthorrhoea* sp.	On flowers	120
Phasmatidae (possibly *Podocanthus* species).	-	Stick insect	N	*X. resinifera*	Nymph, in foliage	305
Phoridae sp.	syrphid fly	Fly	N	*X. australis*	On flowers	283
Phyllotocus rufipennis	-	Beetle	N	*Xanthorrhoea* spp.	Pest on plant	144
Pinnaspis aspidistrae		Scale insect	N	*Xanthorrhoea* spp.	On plant	315
Platysoma sp.	-	Beetle	N	*Xanthorrhoea* sp.	Adults, pupae and probably larvae in decaying caudex	55
Platyzosteria melanaria	-	Cockroach	N	*X. resinifera*	In foliage	305
Platyzosteria sp.	-	Cockroach	N	*X. resinifera*	In foliage	305
Platyzosteria sp. A	-	Cockroach	N	*X. resinifera*	In foliage	305
Plocamocera bivittata	cerambycid beetle	Beetle	N	*Xanthorrhoea* sp.	Host plant, Kuranda Qld	174
Poecilometis eximus	-	Bug	N	*Xanthorrhoea* sp. (Byfield, Qld)	Feeding on flower scape	316
Poecilotoma grandicornis	stinkbug	Bug	N	*X. resinifera*	In foliage	305
Polyrachis sp.	-	Ant	N	*X. preissii*	On recently burnt plants	310
Polyzosteria limbata	-	Cockroach	N	*X. resinifera*	In foliage	305
Porcellio sp.	slater	Isopod	N	*X. resinifera*	In foliage	305
Pompilid wasps	-	Wasp	N	*X. glauca* subsp. *angustifolia*	On flowering spikes	171
Propsednura spp.	-	Grasshopper)	N	*Xanthorrhoea* sp.	On plants	121
Prypnus quinquenodosus	weevil	Beetle	N	*Xanthorrhoea* sp.	On plant	305
Prypnus sp.	weevil	Beetle	N	*Xanthorrhoea* sp.	On plant	305
Prypnus squalidus	weevil	Beetle	N	*Xanthorrhoea* sp.	On plant	305
Psednura spp.	-	Grasshopper	N	*Xanthorrhoea* sp.	On plants	121, 305
Pseudaulacaspis sp.	-	Scale insect	N	*X. australis* *Xanthorrhoea* spp.	On plant. Pest on plant. On plant.	315 144 315
Pseudaulacaspis cockerelli)	-	Scale insect	N	*Xanthorrhoea* spp.	Pest on plant	144
Pseudococcus xanthorrhoeae	-	Mealy bug	N	*X. glauca* subsp. *angustifolia* *Xanthorrhoea* sp. (Bunya Mts) *Xanthorrhoea* spp.	Collected from plants. Collected from leaf bases. On plants.	106 106 315
Psocidae (species unknown)	-	Bark lice	N	*X. australis*	On surface of flowering spike	38
Ptilomacra senex	woodmoth	Moth	N	*Xanthorrhoea* spp.	Larvae bore in grasstrees. Pest on plant.	88, 127 144
Quedius sp.	-	Beetle	N	*Xanthorrhoea* spp.	Pest on plant	144
Radopholus crenatus	burrowing nematode	Nematode	N	*X. semiplana* *Xanthorrhoea* spp.	Pathogen. Pest on plant.	172 144
Radopholus vangundvi	burrowing nematode	Nematode	N	*X. quadrangulata* *Xanthorrhoea* spp.	Pathogen. Pest on plant.	172, 173 144
Reduviidae (species unknown_Western Australia)	assassin bug	Bug	N	*X. preissii*	On recently burnt plants	310
Rhinotia haemoptera	-	Beetle	N	*X. resinifera*	In foliage	305
Rhyparida sp.	-	Beetle	N	*X. resinifera*	In foliage	305
Runcinia sp.	-	Spider	N	*X. resinifera*	In foliage	305
Salticidae (species unknown_eastern Australia)	jumping spider	Spider	N	*X. resinifera*	In foliage	305
Salticidae (species unknown_Western Australia)	jumping spider	Spider	N	*X. preissii*	On plant recently burnt	310
Sauertylenchus sp.	-	Nematode	N	*Xanthorrhoea* spp.	Pest on plant	144
Scaphidium punctipenne	-	Beetle	N	*X. johnsonii*	Adults resting on outer leaves	3
Scopodes sp.	-	Beetle	N	*X. resinifera*	In foliage	305
Scutellonema minutum	-	Nematode	N	*Xanthorrhoea* spp.	Pest on plant	144
Scutellonema sp.	-	Nematode	N	*Xanthorrhoea* spp.	Pest on plant	144
Simosyrphus grandicornis	syrphid fly	Fly	N	*X. australis*	On flowers	283
Staphylinidae (species unknown_eastern Australia)	rove beetle	Beetle	N	*X. resinifera*	In foliage	305
Stephanopsis sp.	crab spider	Spider	N	*X. resinifera*	In foliage	305
Stigmodera gratiosa	jewel beetle	Beetle	N	*Xanthorrhoea* spp.	Visiting flowers	273
Stigmodera sp.	jewel beetle	Beetle	N	*Xanthorrhoea* spp.	Pest on plant	144

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Synechocera elongata	-	Beetle	N	*Xanthorrhoea* sp.	On plant On leaves	124 124
Telicota anisodesma	southern large darter	Butterfly	N	*Xanthorrhoea* sp.	On flowers	145
Telicota colon	pale-orange darter	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar.	120 145
Tenebrionidae (species unknown)	alleculid beetle	Beetle	N	*Xanthorrhoea* sp.	On plant	128
Tettigoniidae (species unknown, possibly *Conocephalus* sp.)	-	Cricket	N	*X. resinifera*	Nymph, in foliage	305
Tettigoniidae(possibly *Tinzeda* species).	-	Katydid	N	*X. resinifera*	Nymph in foliage	305
Tettigoniidae (species unknown_eastern Australia)	-	Cricket	N	*X. resinifera*	Nymph in foliage	305
Tharpyna sp.	-	Spider	N	*X. resinifera*	In foliage	305
Theridiidae sp. (species unknown_Western Australia)	comb-footed spider	Spider	N	*X. preissii*	On freshly burnt plant.	310
Thomisidae (species unknown)	crab spider	Spider	N	*Xanthorrhoea* sp.	On plant	305
Thomisidae (species unknown_Western Australia)	crab spider	Spider	N	*X. preissii*	On freshly burnt plant	310
Tipulidae (species unknown_eastern Australia)	crane fly	Fly	N	*X. resinifera*	Larva, in foliage	305
Tirumala hamata hamata	blue tiger	Butterfly	N	*X. johnsonii*	Adults feeding on nectar	158
Todima sp.	-	Beetle	N	*Xanthorrhoea* spp.	Pest on plant	144
Todima spp.	-	Beetle	N	*Xanthorrhoea* spp.	In leaf bases or on flower stalks	126
Trapezites iacchoides	silver-studded ochre	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feed on nectar.	120 145
Trapezites iacchus	brown ochre	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feeding on nectar.	120 145
Trapezites maheta	northern silver ochre	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feeding on nectar.	120 145
Trapezites petalia	black-ringed ochre	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feeding on nectar.	120 145
Trapezites phigalia phigalia	heath ochre	Butterfly	N	*Xanthorrhoea* sp.	On flowers	120
Trapezites phigalia philus	heath ochre	Butterfly	N	*Xanthorrhoea* sp.	Feeding on nectar	145
Trapezites praxedes	southern silver ochre	Butterfly	N	*Xanthorrhoea* sp.	On flowers. Feeding on nectar.	120 145
Trapezites taori	sandstone ochre	Butterfly	N	*Xanthorrhoea* sp.	Adults feed on nectar	86
Trigona carbonaria	stingless bee	Bee	N	*Xanthorrhoea* sp. *X. johnsonii*	Adults feed on flowers. Feeding on pollen. Adults feed on pollen and nectar.	89, 91 107 90
Trigonotarsus rugosus	weevil	Beetle	N	*X. johnsonii* *X. australis* *Xanthorrhoea* sp.	Adults amongst young leaves. Dead trunk. Larvae bore in caudex near base of trunk, pupae & adults on plants. Larvae burrow in trunk.	3 283 27, 55 163,164
Trypetinae (species unknown)	-	Fly	N	*Xanthorrhoea* sp.	Larvae in decaying caudex; Adults upon leaves	55
Tylodorus fisheri	-	Nematode	N	*X. quadrangulata* *X. semiplana* *X. semiplana* subsp. *tateana*	Pathogen. Pathogen. Pathogen.	173 173 173
Tylodorus sp.	-	Nematode	N	*Xanthorrhoea* spp. *X. quadrangulata* *X. semiplana*	Pathogen. Pathogen. Pathogen.	144 172, 173 172, 173
Uracanthus sp.	longicorn beetle	Beetle	N	*Xanthorrhoea* sp.	On flower spike	124
Vanessa itea	Australian red admiral	Butterfly	N	*X. australis*	On flowers	283

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Vanessa kershawi	Australian painted lady	Butterfly	N	*X. johnsonii* *X. australis*	Adults on flowers. Adult on flowers.	158 283
Xantholinus erythropterus	rove beetle	Beetle	N	*Xanthorrhoea* sp.	Larvae and adults between sheath and caudex	55
Xiphinema monohysterum	-	Nematode	N	*X. quadrangulata*	Pathogen	173
Xylocopa aeratus (jun. syn. *Lestis aeratus*)	carpenter bee	Bee	N	*Xanthorrhoea* sp. *X. semiplana* subsp. *tateana* *X. arborea*	Nest inside dead flower stems. Nest in flower stems. Nest in dead flower scapes. Nest in dead flower scapes.	89, 93 291 307 307
Xylocopa sp. (jun. syn. *Lestis* sp.)	carpenter bee	Bee	N	*Xanthorrhoea* spp. *Xanthorrhoea* sp.	Pest on plant. Nest in flower stalks, Tuan Qld.	144 145
Xylocopa bombiliformis (jun. syn. *Lestis bombiliformis*)	carpenter bee	Bee	N	*Xanthorrhoea* sp. *X. arborea* *X. johnsonii* *X. fulva*	Nest inside dead flower stems. Adults feed on flowers. Nest in dead flower scapes. Nest in dead flower scapes. Nest in dead flower scapes	55, 89, 92 89 307 307 307
Zaprochilus australis	-	Katydid	N	*Xanthorrhoea* sp. *X. australis*	Adult feeds on nectar and pollen. Nymphs at base of flower stalks. Adults and nymphs sheltering in leaves	84, 128, 129 128 128
Zaprochilus mongabarra	-	Katydid	N	*X. australis*	Sheltering in leaves	128

Table 9: Vertebrate species utilizing *Xanthorrhoea* species.
* = introduced species; Queensland Conservation Status: C = common; R = rare; V = vulnerable; NP = not protected in Queensland; - = WILDNET does not list for Queensland

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Acanthiza sp.	thornbills	Bird		*Xanthorrhoea* spp.	Feeding on flowers, but probably taking insects rather than nectar	243
Acanthiza chrysorrhoa	yellow-rumped thornbill	Bird	C	*Xanthorrhoea* sp. *X. preissii*	Nest site. Nest site.	68 57, 69
Acanthiza inornata	western thornbill	Bird	-	*X. preissii* *Xanthorrhoea* sp.	Nest site. Nest site.	57, 69 67
Acanthiza lineata	striated thornbill	Bird	C	*Xanthorrhoea* sp.	Feeding on nectar	25
Acanthiza pusilla	brown thornbill	Bird	C	*Xanthorrhoea* sp. *X. australis*	Feeding on nectar Feeding on nectar	25 56
Acanthiza reguloides	buff-rumped thornbill	Bird	C	*Xanthorrhoea* sp.	Nest site	58, 59
Acanthorhynchus sp.	spinebill	Bird	-	*X. semiplana*	Feeding on flowers	321
Acanthorhynchus superciliosus	western spinebill	Bird	-	*Xanthorrhoea* sp.	Feeding on nectar	54, 250
Acanthorhynchus tenuirostris	eastern spinebill	Bird	C	*X. semiplana* *X. australis*	Feeding on nectar & pollen. Feeding on nectar.	32 56
Acrobates pygmaeus	feathertail glider	Arboreal marsupial	C	*Xanthorrhoea* spp.	Feeding on flowers and nesting in dead leaves	252
Amphibolurus muricatus	jacky lizard	Reptile	C	*Xanthorrhoea* sp.	On flower spike	219
Anthochaera carunculata	red wattlebird	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. semiplana* *X. drummondii* *X. preissii*	Feeding on flowers. Visit and pollinate flowers. Feed on nectar and insects attracted to flowers. Visiting flowers Feed on nectar and pollen. Feeding on flowers. Visiting flowers. Feeding on flowers. Visiting flowers.	33 243 250 44 32 29 273 29 273
Anthochaera chrysoptera	little wattlebird	Bird	C	*X. australis*	Feeding on nectar	43
Anthochaera sp.	wattlebird	Bird	-	*X. semiplana*	Feeding on flowers	321
Antechinus stuartii	brown antechinus		C	*X. australis* *X. media*	Nest sites at ground level under large plants. Feeding on flowers (pollen in faeces).	188 287, 299

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Artamus cinereus	black-faced woodswallow	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. preissii*	Feeding on seeds. Visiting flowers Feeding on flowers. Visiting flowers.	25 44 29 273
Artamus cyanopterus	dusky woodswallow	Bird	C	*Xanthorrhoea* sp. *X. pressii*	Feeding on nectar. Nest site.	35 69
Artamus superciliosus	white-browed woodswallow	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp.	Feeding on nectar. Visiting flowers.	26 44
Aves (unknown species)	honeyeaters	Bird		*X. glauca* subsp. *angustifolia*	On flowering spikes	171, 218
Aves (unknown species)	lorikeets	Bird	-	*X. semiplana*	Feeding on flowers	321
Aves (unknown species)	parrots	Bird	-	*X. semiplana*	Feeding on flowers	321
Aves (unknown species)	robins and wrens	Bird		*Xanthorrhoea* spp.	Feed on insects visiting flowers	250
Aves (unknown nectar-feeding bird species)		Bird		*Xanthorrhoea* sp.	Feeding on nectar	211
Aves (unknown species)		Bird		*Xanthorrhoea* sp. *X. preissii* *X. glauca* subsp. *angustifolia*	Nest in foliage. Dead stumps used as feeding perches for birds feeding on the jewel beetle *Julodimorpha bakewelli*. Nesting in skirts of dead leaves on plants. On flower spikes during flowering and seed development.	211 160 171 104
Barnardius zonarius semitorquatus	Port Lincoln ringneck (twenty-eight parrot)	Bird	C	*Xanthorrhoea* sp. *X. preissii*	Feeding on plant. Feeding on seeds. Feeding on leaves.	226 48 147
Bos spp.*	cattle	Bovidae	-	*Xanthorrhoea* spp. *X. fulva* *X. johnsonii* *X. minor* *X. resinifera*	Feeding on inflorescences. Feeding on leaves. Feeding on young leaves of apical meristem. Feeding on plant. Feeding on young inflorescences. Feeding on young inflorescences. Feeding on leaves and inflorescences. Feeding on leaves and inflorescences. Feeding on inflorescences.	108,112 112 328 152 109 109, 110, 111 112 112 110
Brachyurophis semifasciatus	half-ringed snake		-	*Xanthorrhoea* sp.	In decaying plant	250
Cacatua leadbeateri	pink cockatoo	Bird	V	*Xanthorrhoea* sp.	Feeding on seeds	25
Cacatua galerita	sulphur-crested cockatoo	Bird	C	*X. semiplana*	Feed on flower spikes. Feeding on seeds.	36 37, 119
Calyptorhynchus spp.	black cockatoos	Bird		*Xanthorrhoea* sp.	Feeding on beetle larvae in dead flower spikes	37
Calyptorhynchus funereus	yellow-tailed black cockatoo	Bird	C	*Xanthorrhoea* sp. *X. fulva*	Feeding on lepidoptera larvae (*Meyriccia latro*) in flower spikes. Extracting grubs from inflorescences. Feeding on inflorescences.	38 136, 211 102
Calyptorhynchus latirostris	short-billed black-cockatoo	Bird	C	*X. preissii*	Demolishing mantles of recently dead plants	69
Cercartetus concinnus	western pygmy-possum	Arboreal marsupial	-	*Xanthorrhoea* spp.	Nest in leaves	253
Cercartetus nanus	eastern pygmy possum	Arboreal marsupial	C	*X. australis*	Nest in skirt of dead leaves of live plants and rotting centres of dead stumps	254
Cercartetus sp.	pygmy-possum	Arboreal marsupial	C	*Xanthorrhoea* sp.	Shelter and/or nest in foliage. Nest in dead leaves.	211 250
Cinclosoma punctatum	spotted quail-thrush	Bird	C	*Xanthorrhoea* sp.	Nest site	74
Dromaius novaehollandie	emu	Bird	C	*Xanthorrhoea* sp.	Feeding on broken scapes	35
Eopsaltria georgiana	white-breasted robin	Bird	-	*Xanthorrhoea* sp.	Nest site	72
Eopsaltria griseogularis	western yellow robin	Bird	-	*Xanthorrhoea* sp.	Nest site	71
Entomyzon cyanotis	blue-faced honeyeater	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp.	Feeding on nectar. Nest site. Visiting flowers.	26 60 44
*Equus caballus**	brumby	Horse	-	*Xanthorrhoea* sp.	Feeding on young leaves of apical meristem	328

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Geopelia cuneata	diamond dove	Bird	C	*Xanthorrhoea* sp.	Nest site	75
Glossopsitta concinna	musk lorikeet	Bird	C	*X. australis*	Feeding on nectar	43
Glossopsitta porphyrocephala	purple-crowned lorikeet	Bird	C	*Xanthorrhoea* spp. *X. semiplana*	Visit and pollinate flowers. Feeding on nectar. Feeding on nectar and pollen.	243 250 32
Hylacola pyrrhopygia	chestnut-rumped heathwren	Bird	C	*Xanthorrhoea* sp.	Nest site	66
Isoodon obesulus	southern brown bandicoot	Medium sized marsupial	-	*X. australis* *X. semiplana*	Nest under well-developed skirts of living and dead foliage that reach the ground. Nest under foliage that reaches ground.	292, 335 335
Lathamus discolor	swift parrot	Bird	C	*Xanthorrhoea* sp.	Feeding on seeds & nectar	39
Lichenostomus chrysops	yellow-faced honeyeater	Bird	C	*X. semiplana*	Feeding on nectar, pollen and insects	32
Lichenostomus leucotis	white-eared honeyeater	Bird	C	*Xanthorrhoea* sp	Nest site	61
Lichenostomus melanops	yellow-tufted honeyeater	Bird	C	*Xanthorrhoea* sp.	Feeding on flowers	28
Lichenostomus ornatus	yellow-plumed honeyeater	Bird	C	*X. australis*	Feeding on nectar	43
Lichenostomus penicillatus	white-plumed honeyeater	Bird	C	*X. australis*	Feeding on nectar	43
Lichenostomus sp.	honeyeater	Bird	-	*X. semiplana*	Feeding on flowers	321
Lichenostomus virescens	singing honeyeater	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. preissii*	Feeding on nectar. Visiting flowers. Feeding on nectar and insects visiting flowers. Feeding on flowers. Visiting flowers.	45 44 250 29 273
Lichmera indistincta	brown honeyeater	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. preissii*	Feeding on nectar. Nest site. Feeding on nectar and insects visiting flowers. Visiting flowers. Nest site.	26 62 250 29, 44, 273 69
Macroglossus minimus	northern blossom bat	Bat	C	*Xanthorrhoea*	Misted netted around flowering plants	259
Macropodidae (unknown species)	wallabies and kangaroos	Large marsupial	-	*Xanthorrhoea* spp.	Shelter under plants	300
Macropus fuliginosus	western grey kangaroo	Large marsupial	C	*X. preissii* *X. gracilis*	Feeding on leaves. Grazing on seedlings. Grazing on seedlings.	152, 159 240 240
Malurus cyaneus	superb fairy-wren	Bird	C	*Xanthorrhoea* sp.	Important habitat	36
Malurus splendens	splendid fairy-wren	Bird	C	*X. preissii*	Nest site	57, 69
Manorina melanocephala	noisy minor	Bird	C	*X. australis*	Feeding on nectar	43
Melithreptus brevirostris	brown-headed honeyeater	Bird	C	*Xanthorrhoea* sp. *X. semiplana* *Xanthorrhoea* spp.	Feeding on nectar. Feeding on nectar, pollen and insects. Visiting and pollinating flowers.	45 32 243
Melithreptus gularis	black-chinned honeyeater	Bird	R	*X. australis*	Feeding on nectar	43
Melithreptus lunatus	white-naped honeyeater	Bird	C	*Xanthorrhoea* spp.	Feeding on nectar and insects visiting flowers	250
Melithreptus sp.	honeyeater	Bird	-	*X. semiplana*	Feeding on flowers	321
Merops ornatus	rainbow bee-eater	Bird	C	*X. glauca* subsp. *angustifolia*	Visit flowering spikes	218
Neochmia temporalis	red-browed finch	Bird	C	*X. preissii*	Nest site	69
Ninox novaeseelandiae	southern boobook owl	Bird	C	*Xanthorrhoea* spp.	Feed on small animals attracted to nectar or nest in leaves	250
Notechis scutatus	tiger snake	Reptile	C	*Xanthorrhoea* sp.	Refuge on ground under plant foliage	293
Oedura castelnaui	northern velvet gecko	Reptile	C	*Xanthorrhoea* spp.	Under dead leaf skirts	365
Oreoica gutturalis	crested bellbird	Bird	C	*Xanthorrhoea* sp.	Nest site in fork of trunk or amongst leaves	64
*Oryctolagus cuniculus**	European rabbit	Introduced mammal	NP	*X. glauca* subsp. *angustifolia*	Feeding on new leaves. Graze on seedlings. Graze on new leaves and inflorescences of leaning arborescent plants.	104 138 218
*Ovis aries**	sheep	Domestic stock	NP	*X. preissii* *X. semiplana* and/or *X. quadrangulata*	Feeding on foliage. Feeding on foliage.	152 229

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Parantechinus apicalis	dibbler	Small marsupial	-	*Xanthorrhoea* sp.	Nest sites in dead leaves or dead trunks	78
Parasuta gouldii	Gould's hooded snake (little whip snake)	Reptile	-	*Xanthorrhoea* sp.	In decaying plants	250
Petaurus breviceps	sugar glider	Arboreal marsupial	C	*Xanthorrhoea* sp. *X. johnsonii* *X. glauca* subsp. *angustifolia*	Feeding on nectar or pollen. Feeding on nectar. On flowering spike. Feeding on flowers.	318 8 171 218
Petaurus gracilis	mahogany glider	Arboreal marsupial	E	*X. johnsonii*	Feeding on nectar, pollen, unopened flowers & exudate from young scapes	2, 5, 8
Petaurus norfolcensis	squirrel glider	Arboreal marsupial	C	*Xanthorrhoea* sp. *X. glauca* subsp. *angustifolia*	Feeding on flowers. Feeding on nectar. On flowering spike.	50 51 171
Petroica multicolor	scarlet robin	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. preissii*	Nest site. Feed on insects visiting flowers. Nest site.	70 250 69
Pezoporus wallicus	ground parrot	Bird	V	*Xanthorrhoea* sp. *X. resinifera*	Feeding on seeds. Nest site on ground under foliage. Feeding on seeds.	37, 80 35 139
Phascogale calura	red-tailed phascogale	Small marsupial	-	*Xanthorrhoea* sp.	Nest/refuge sites	83
Philemon corniculatus	noisy friarbird	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. fulva* *X. glauca* subsp. *angustifolia* *X. australis*	Feeding on nectar. Visiting flowers. Feeding on nectar. On flowering spike. On flowers.	26 44 30 171 283
Phylidonyris melanops	tawny-crowned honeyeater	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. semiplana* *X. pressii*	Feeding on flowers. Nest site in drooping leaves. Visiting and pollinating flowers. Feeding on nectar and insects visiting flowers. Feeding on nectar, pollen and insects. Nest site.	33 64 243 250 32 69
Phylidonyris nigra	white-cheeked honeyeater	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. fulva* *X. arborea* *X. pressii*	Feeding on nectar. Nest site. Visiting flowers. Feeding on flowers. Feeding on nectar. Nest site.	26 63 44 30 31 69
Phylidonyris novaehollandiae	New Holland honeyeater	Bird	C	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. arborea* *X. semiplana* *X. preissii*	Feeding on flowers. Feeding on nectar. Nest site. Visiting and pollinating flowers. Feeding on nectar and insects visiting flowers. Feeding on nectar. Feeding on nectar, pollen and insects. Feeding on nectar. Feeding on nectar. Visiting flowers.	33 34, 45 47 243 250 31 32 47 47 273
Phylidonyris pyrrhoptera	crescent honeyeater	Bird	-	*Xanthorrhoea* sp. *Xanthorrhoea* spp. *X. semiplana*	Feeding on flowers. Visiting and pollinating flowers. Feeding on nectar, pollen and insects.	33 243 32
Phylidonyris sp.	honeyeater	Bird	-	*X. semiplana*	Visit flowers	321
Platycercus adelaidae	Adelaide rosella	Bird	C	*X. spatha*	Feeding on seeds	41
Platycercus adscitus	pale-headed rosella	Bird	C	*X. johnsonii*	Feeding on seeds on the flower spikes	158
Platycercus eximius	white-cheeked rosella	Bird	C	*Xanthorrhoea* sp.	Feeding on flowers	40
Platycercus elegans	crimson rosella	Bird	C	*Xanthorrhoea* sp. *X. semiplana*	Feeding on flowers. Feeding on Nectar/pollen.	40 32
Podargus strigoides	tawny frogmouth	Bird	C	*Xanthorrhoea* spp.	Feeding on larger insects visiting flowers at night	250
Pogona barbata	common bearded dragon	Lizard	C	*X. johnsonii*	On flower spike	158

TAXON	COMMON NAME	ANIMAL TYPE	QLD STATUS	SPECIES UTILIZED	USE/LOCATION	LITERATURE REFERENCE
Pseudomys shortridgei	heath rat	Rodent	-	*Xanthorrhoea* sp.	Shelter and/or nest in foliage	211
Psophodes nigrogularis	western whipbird	Bird	-	*X. semiplana* and/or *X. australis*	Nest site	73
Pteropus poliocephalus	grey-headed flying-fox	Bat		*Xanthorrhoea* spp.	Feed on flowers	298
Purpureicephalus spurius	red-capped parrot	Bird	C	*X. preissii*	Feeding on seeds	69
Rattus fuscipes	bush rat	Rodent	C	*Xanthorrhoea* sp. *X. johnsonii*	Nest on ground under foliage skirt. Nesting and cover under ground-level foliage skirts.	301 354
Rodentia (unknown rodent species)		Rodent		*X. fulva*	Feeding on seeds from inflorescences gnawed through and felled to ground.	102
Sericornis frontalis	white-browed scrubwren	Bird	C	*Xanthorrhoea* sp *X. preissii*	Nest site. Nest site.	65 69
Sminthopsis aitkeni	Kangaroo Island dunnart	Small marsupial	-	*Xanthorrhoea* sp.	Nest/refuge site	83, 211
Sminthopsis leucopus	white-footed dunnart	Small marsupial	R	*X. australis*	Sheltering under plants, nesting inside dead stump, climbing inflorescences	256
Sminthopsis murina	common dunnart	Small marsupial	C	*Xanthorrhoea* sp.	Shelter and/or nest in foliage	211
Squamata (unknown lizard species)		Reptile		*Xanthorrhoea* sp.	Shelter in foliage	211
*Streptopelia senegalensis**	laughing turtle-dove	Bird	-	*X. preissii*	Nest site	69
*Sturnus australis**	European starling	Bird	NP	*X. australis*	Feeding on nectar	43
Syconycteris australis	Queensland blossom bat	Bat	C	*Xanthorrhoea* sp.	Feeding on flowers. Mist-netted around flowering plants.	76 77, 259
Tarsipes rostratus	honey possum	Arboreal marsupial	-	*Xanthorrhoea* spp.	Shelter in old bird nests in the bushy heads of grasstrees. Shelter in the hollow stems of grasstrees.	250 251
Trichoglossus chlorolepidotus	scaly-breasted lorikeet	Bird	C	*Xanthorrhoea* sp.	On plant but usage not detailed. Feeding on flowers.	37 77, 119
Trichoglossus haematodus	rainbow lorikeet	Bird	C	*Xanthorrhoea* sp.	Feeding on flowers	37, 77,79,119
Trichosurus vulpecula	common brushtail possum	Arboreal marsupial	C	*X. johnsonii* *X. australis*	Chew young, green flower stems. This possum thought probably responsible for chewing on immature scapes.	158 218
Underwoodisaurus milii	thick-tailed gecko	Reptile	C	*Xanthorrhoea* spp.	Associated with plant but no detail given (probably refuge site)	250
Vermicella sp.	bandy-bandy (snake)	Reptile	C	*Xanthorrhoea* spp.	In decaying plants	250
Xanthotis macleayana	Macleay's honeyeater	Bird	C	*Xanthorrhoea* sp.	Feeding on flowers	42
Zosterops lateralis	Silvereye	Bird	C	*Xanthorrhoea* spp. *Xanthorrhoea* sp. *(preissii?)* *X. preissii* *X. semiplana*	Visiting and pollinating flowers. Visiting flowers. Nest site. Visiting flowers.	243 273 69 303

Table 10: Fungi recorded on *Xanthorrhoea* species.

TAXON	COMMON NAME	SPECIES UTILIZED	COMMENT	LITERATURE REFERENCE
Agaricostilbum pulcherrimum	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Alternaria alternata	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Amphisphaerella petrakii	-	*Xanthorrhoea* sp.	Collected at Timbeerwah Qld	169
Anthostomella bispapillatus	-	*Xanthorrhoea* spp.	Saprobe[311]	144
Anthostomella hemibrunnea	-	*Xanthorrhoea* spp.	Saprobe[311]	144
Anthostomella pseudoclypeata	-	*Xanthorrhoea* spp.	Saprobe[311]	144
Anthostomella sp.	-	*Xanthorrhoea* spp.	Saprobe[311]	144
Arthrinium sacchari	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Armillaria luteobubalina	-	*Xanthorrhoea* spp. *X. australis*	Pest on plant. Causes root rot.	144 168
Avettaea alcornii	-	*Xanthorrhoea* sp.	On foliage collected at Cunningham's Gap National Park in SE Qld.	169
Botryosphaeria xanthorrhoeae	-	*Xanthorrhoea* spp. *Xanthorrhoea* sp. *X. semiplana*	Pest on plant. Pathogen[311] on plant at Mt Nebo Qld. Pathogen on scapes. Pathogen.[311]	144 169 172 169

TAXON	COMMON NAME	SPECIES UTILIZED	COMMENT	LITERATURE REFERENCE
Capnodium sp.	-	*Xanthorrhoea* spp.	sooty mould[311]	144
Circinotrichum olivaceum	-	*Xanthorrhoea* spp.		169
Colletotrichum xanthorrhoeae	-	*Xanthorrhoea* spp. *X. preissii* *X. platyphylla* *X. gracilis*	Pest on plant. Causes leaf spots. Causes leaf spots. Causes leaf spots.	144 146 146 166
Coniothyrium xanthorrhoeae	-	*Xanthorrhoea* spp.	Saprobe[311]	144, 169
Cryptocoryneum rilstonii	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Cryptophiale udagawae	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Epicoccum nigrum	-	*Xanthorrhoea* spp.	Saprobe	169
Gilmaniella punctiformis	-	*Xanthorrhoea* spp.	Saprobe[311] on dead leaves collected at Mt Nebo and Moggill State Forest, SE Qld.	169
Gloniopsis praelonga	-	*Xanthorrhoea* sp.	Saprobe[311] on dead leaves collected at Mt Nebo in Qld.	169
Glonium xanthorrhoeae	-	*Xanthorrhoea* sp.	Saprobe[311] on dead leaves collected at Mt Nebo in Qld.	169
Gyrothrix circinata	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Herposira velutina	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Lophiostoma caulium	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Microdiplodia sp.	-	*Xanthorrhoea* spp. *X. preissii*	Pathogen.[311] Causes leaf spots.	144 168
Paliphora aurea	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Periconia echinochloae	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Pestalotiopsis versicolor	-	*Xanthorrhoea* spp.	Saprobe	169
Phaeoisaria clematidis	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Phaeoseptoria xanthorrhoeae	-	*Xanthorrhoea* spp.	Pathogen[311] associated with distinct lesions towards the apex of a leaf	169
Phaeostalagmus cyclosporus	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Phomopsis sp.	-	*Xanthorrhoea* spp.		144
Phytophthora cinnamomi	-	*Xanthorrhoea* spp. *X. australis* *X. preissii* *X. reflexa* *X. preissii* *X. semiplana* *X. s. tateana* *X. platyphylla* *X. arenaria* *X. bracteata* *X. quadrangulata* *X. semiplana* *X. semiplana* subsp. *tateana*	Pest on plant. Extremely damaging pest species. Causes dieback and fatal root rot.[311] Causes root rot. Causes root rot. Fatal root rot. Pathogen. Pathogen. Fatal root rot. Fatal root rot. Fatal root rot. Fatal root rot. Fatal root rot. Fatal root rot.	144 167 175, 176, 186, 189 168 168 190 172 172 191 186, 204 204 212 212 212
Phytophthora cryptogea	-	*Xanthorrhoea* spp. *X. semiplana*	Associated with root rot.[311] Associated with root rot.[311]	144 172
Pseudospiropes rousselianus	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Pseudospiropes verruculosus	-	*Xanthorrhoea* spp.	Saprobe[311] on leaves	169
Ramichloridium indicum	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Sporidesmium brachypus	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Sporothrix ghanensis	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Torula herbarum f. *quaternella*	-	*Xanthorrhoea* spp.	Saprobe	169
Trichopeziza citro-alba	-	*Xanthorrhoea* spp.	Saprobe[311]	169
Vizella xanthorrhoeae	-	*Xanthorrhoea* spp. *X. arborea*	Pest on plant. Grows in leaf cuticle.	144 169
Zygosporium gibbum	-	*Xanthorrhoea* spp.	Saprobe	169

4.7.2 Grazing

Domestic stock and other animals are known to graze *Xanthorrhoea*. This grazing can affect both the grazing animal, the plant and potentially other animals that utilize the plant.

4.7.2.1 Grazing impact on *Xanthorrhoea*

Sheep[152] and cattle[108,109,110,111,152] are reported to feed on *Xanthorrhoea* with both foliage and young green inflorescences either eaten or chewed. No published information was found citing goats, horses or other domestic animals feeding on *Xanthorrhoea*. Although domestic stock have the potential to break or damage *Xanthorrhoea* through grazing, trampling or rubbing, the impact may not always be fatal to the plant. In *X. australis* breakage or damage to arborescent stems is not always fatal as it can result in axillary and adventitious shoots and adventitious roots.[157] However, it is believed most arborescent *Xanthorrhoea* species would not survive complete decapitation.[264]

It is reported that persistent heavy grazing of very small *X. australis* can be a "potent mortality factor",[155] but the author fails to identify whether this is stock grazing or grazing by other animals (e.g. rabbits or native animals). Observations indicate that *Xanthorrhoea* regeneration does not occur in heavily grazed areas, although the effects of moderate grazing are considered to be probably inconsequential.[264] Grazing by what is believed to be western grey kangaroos (*Macropus fuliginosus*), had a detrimental impact on seedling survival and growth in *X. gracilis* and *X. preissii* on restored mine sites in Western Australia.[240] It is also believed that the rarity or lack of *Xanthorrhea* seedlings in unmined jarrah forest in Western Australia is because of heavy grazing by kangaroos.[240] In a Victorian study of *X. glauca* subsp. *angustifolia* (ex *X. australis*), the total number of seedlings and young plants on sites fenced to exclude rabbits and small macropods was significantly higher at the end of a 10-year period.[218]

Young green *Xanthorrhoea* inflorescences are eaten or chewed by cattle,[109,110,111,112] and by other mammals such as rabbits and possums.[218] Feeding on the inflorescence could have a significant impact on seed production. This impact has been partly quantified for *X. glauca* subsp. *angustifolia* (ex *X. australis*) in Victoria and *X. johnsonii* in south-east Queensland. In some years of a 10-year study of *X. glauca* subsp. *angustifolia*, almost 80 percent of the inflorescences on some sites were grazed by herbivores, resulting in destruction of the inflorescence or greatly reduced seed production.[218] For *X. johnsonii*, possum damage to flower spikes on five study sites ranged from around 11 percent up to 23 percent, mean estimated damage at just over 14 percent.[90]

Fire may also affect how herbivores interact with *Xanthorrhoea*. When fire burns away the needle-like leaves protecting the apical meristem and surrounding softer growing leaves of arborescent *Xanthorrhoea*, exposure of these softer parts to herbivores is markedly increased.[152] Once damaged in this way, *Xanthorrhoea* plants can receive on-going visits by herbivores, which in some cases has lead to plant deaths.[147] Slow vertical growth of arborescent *Xanthorrhoea* species[10,11,12,101,104,199] exposes them to grazing by stock for potentially 75–100 years or more. Slow growing species such as *Xanthorrhoea*, even if capable of surviving chronic herbivory, may suffer other grazing related effects. *Xanthorrhoea preissii* showed a strong capacity to recover from leaf clipping (=grazing or leaf harvest), even after clipping every month for 16 months.[152] However, clipping depleted starch reserves in the desmium of the plants, thus providing a possible cause for deterioration of plant health.[152] Studies into the effect of clipping (=grazing or leaf harvest) on flowering in *Xanthorrhoea* have produced mixed results. Clipping induced flowering in *X. fulva*.[102] In another study clipping also induced flowering in *X. australis,*[12] while clipping leaves to ground level on trunkless *X. australis* in South Australia failed to induce flowering.[136]

4.7.2.2 Impact of *Xanthorrhoea* on stock

Although it is believed all *Xanthorrhoea* species are likely to be poisonous to cattle,[108] it is mainly based on field reporting of poisonings[109,110,111] rather than well designed feeding/clinical trials. Animals poisoned by *Xanthorrhoea* develop a staggering, un-coordinated gait known as "wamps", urine dribbling and loss of condition.[9,108,109,112] The condition is also called "crampy wamps", "crampy disease", "staggers", "cripples", "wallum disease" or "rickets".[96,110,111,112] In some cases it has been reported that eye cataracts also develop causing part or partial blindness, although it has not been confirmed that this is a direct result of grass-tree poisoning.[96,111,112] *Xanthorrhoea* poisoning can lead to collapse with resultant starvation and/or dehydration killing the animal.[9,113] In south-east Queensland, grasstree poisoning is usually in winter and spring, while in north Queensland it is common in autumn and early winter.[96] Most likely animals to be affected are newly introduced cattle and those grazing mineral deficient country.[96] Unless the condition is severe, removing cattle from access to grasstrees will result in complete recovery of poisoned animals.[96] Field reporting indicates eating of the young flower scapes/spikes might be the cause of *Xanthorrhoea* poisoning in cattle.[109,110,111]

Xanthorrhoea feeding trials have been limited, lack controls and have had mixed results. In 1914, Cleland fed a calf for six months on *Xanthorrhoea* shoots, scapes and young leaves mixed with chaff and supplemented with lucerne hay, but no symptoms of illness were produced.[110] Pound in 1913–14 fed yearling calves for two and half months on chaffed *Xanthorrhoea* (=*X. latifolia*, *X. johnsonii* or hybrid[112]) mixed with grain, but no symptoms of illness were produced.[110] McGrath in 1928 fed a cow for six months on *Xanthorrhoea* leaves, again with no symptoms of illness produced.[110] A. Seawright reports on experiments in 1937–38 and post-war prior to 1955, where leaves of *X. media* (=*latifolia or johnsonii*) when fed to cattle also did not induce symptoms of illness.[111] W. Hall in 1953–5 fed four cattle with *X. hastile (=fulva*) flower spikes of various maturity (either chaffed or cut into small pieces) and mixed with either lucerne, oats and lucerne chaff or oats chaff, with two of the animals developing symptoms consistent with field reports of *Xanthorrhoea* poisoning.[109, 133, 134] Definite clinical symptoms of poisoning did not start showing up in the two animals until 10 and 32 days after *Xanthorrhoea* was removed from the diet, one animal eventually recovering fully, the second dying.[109,134] Field evidence and feeding trials indicate the leaves of most *Xanthorrhoea* species are almost certainly non-toxic;[112,132] although there is evidence this may not the case in at least one species.[135] The toxic component appears confined to the inflorescences, especially the young flower spikes, with evidence in at least one species that the scape (stalk) maybe more toxic than the spike.[112] Although the toxin is unknown, it is thought to be a phenolic component.[9]

4.7.3 Fire

Information available suggests fire plays a complex role in the life cycle of *Xanthorrhoea* species.

4.7.3.1 Fuel and burning

Xanthorrhoeas are highly combustible,[11,101,104,117,199,218,241] and arborescent plants can accumulate significant amounts of fuel.[12,104,161,218,290,front cover] Dead leaf build up on a single-stemmed *X. australis* can be as much as 0.5kg per year,[12] with similar dead leaf accumulation recorded for *X. preissii*.[241] In *X. preissii*, this skirt of dead leaves can "lock up" magnesium, calcium, boron, iron and aluminium, to a lesser extent nitrogen and to a variable extent, zinc and magnesium.[241] Fire maybe important in releasing these and other elements in both dead and live leaves. Ash forms above about 500^{o}C,[288] and can return large amounts of nutrients to the soil around *Xanthorrhoea* plants.[241] However, burning also volatises almost all the nitrogen and sulphur in the leaves burnt.[241] Ethylene gas is also released when *Xanthorrhoea* are burnt.[218] During a fire temperatures of combustion around live, mature *Xanthorrhoea* leaves can range from 130^{o}C to greater than 600^{o}C, and around 450–1020^{o}C for dead leaves.[241] Dead leaves generally burn at temperatures greater than 500^{o}C.[241] For *X. glauca* subsp. *angustifolia* (ex *X. australis*) with dry leaf skirts, burning has been shown to raise above-ground air temperatures around individual plants to as high as 800^{o}C for short periods.[218] The lethal fire temperature for green, *X. gracilis* leaves is 41–46^{o}C.[275]

4.7.3.2 Response to fire

A number of *Xanthorrhoea* species have been recorded resprouting after fire and include *X. australis*,[12,136,161,246,277] *X. drummondii*,[137,194] *X. glauca* subsp *angustifolia* (ex *X. australis*),[104,218] *X. gracilis*,[194,195,345] *X. johnsonii*,[10,356] *X. preissii*[11,152,156,194,195,309] and *X. semiplana*.[244] It wouldn't be unexpected if all or most *Xanthorrhoea* species can resprout after fire. Leaf production in *X. johnsonii* was elevated for at least up to 240 days post-fire.[10] There was no interruption to leaf production in *X. pressii* by the passage of fire,[241] instead leaf production was accelerated.[152] Post-fire leaf production also increases in *X. johnsonii*.[10] This accelerated post-fire leaf production occurs in *X. preissii* regardless of season when the fire occurs.[152] Rapid leaf growth in *X. preissii* immediately post-fire was partly at the expense of starch reserves in the stem.[152] Although this initial rapid growth was relatively short-lived (12–32 weeks), elevated leaf production levels were sustained for up to 19 months.[152] The rapid post-fire leaf regrowth usually restores leaf biomass within 25 weeks.[329] Mean maximum leaf production was higher in *X. preissii* burnt in spring (up to 6.1 leaves/day) compared to those burnt in autumn (up to 4.5 leaves/day).[152] This was thought to be due to optimum growing conditions in late spring/early summer in Western Australia.[152]

It is believed the rapid regrowth of *X. preissii* leaves following fire is the result of increased nutrient availability following fire.[152] This nutrient increase is indicated by the elevation of post-fire leaf-base concentrations of nitrogen, calcium, potassium and zinc.[153,154] However, a number of other factors potentially behind this accelerated growth have been examined. It was found that either an application of fire ash or reduced shade increased leaf growth, but their effects were small compared with the stimulation of leaf growth by the leaf clipping effect of fire.[152]

The apical region of *Xanthorrhoea*, when above ground, is well protected from fire by its young, succulent, closely packed leaf bases.[12,199,198] *Xanthorrhoea* are also protected from fire by having a high internal moisture content and a trunk with an outer covering of resin-cemented leafbases on which fire cannot usually burn long enough to kill the plant.[198] Because the vascular system (xylem and phloem) is distributed throughout the insulated trunk, it is thought this may also provide some protection from fire.[290] However, this type of vascular system occurs in all monocots and not all monocots can be considered fire resistant.[357] When fire burns the green crown of a *Xanthorrhoea*, leaf regrowth occurs from the undamaged basal leaf-meristems.[12,155,156] In *X. preissii* fire damage to the apical region is believed to be responsible for producing multiple growing apices.[156] Except at a very early seedling stage, the apical meristem of younger *X. australis* and *X. glauca* subsp. *angustifolia* (stem diameter ~<12cm) are protected underground from fire.[12,218] Following germination, the contractile roots draw the apical meristem of *X. australis* up to 12cm below ground.[12] This protection is afforded once the apex is drawn about 2cm below the surface.[218] Glasshouse grown *X. australis* seedlings had apical meristems that were drawn down at up to 1cm per month.[155]

The ability of the *Xanthorrhoea* apical meristematic region to survive fire has been used in the non-arborescent *X. gracilis* to measure fire intensity in jarrah forest fires in Western Australia.[275] A relationship was found between fire intensity and the length of dead leaf tissue (scorched leaf) between the burnt tip and the unburnt green living portions of the leaf.[275] However, a similar investigation near Sydney found leaf scorch lengths highly variable in *X. resinifera* (non-arborescent to >60cm trunk height).[276] This study concluded that the "minimum branch tip diameter" method applied to *Banksia oblongifolia* was a more reliable *post-hoc* index of fire intensity.[276]

In spite of the protective mechanisms that *Xanthorrhoea* have evolved to survive fire, mortality from fire does occur. Research indicates some species maybe more resilient to fire and that fire intensity maybe a factor.[241] It is believed by some that fire is beneficial to *Xanthorrhoea*, while other see fire as a significant threat. One view is that frequent fire can lead to healthier *X. preissii* in the tuart forest of southwestern Australia. At this location long-unburnt *X. preissii* were developing massive loads of dead leaf thatch leading to trunk rot and termite invasion, as well as putting the plant at greater risk of death from wildfire fire because of the fuel load build up in the leaf thatch.[340] Fire is reported to kill *X. preissii* in intense wildfires.[101,346] A Victorian study found prescribed burning resulted in 21 percent mortality of arborescent *X. glauca* subsp. *angustifolia (ex X. australis)*, with highest mortality in the youngest and oldest plants.[104,218] Plants were still dying in the second year following fire.[104] Sites on steeper slopes (<15 percent) had *X. glauca* subsp. *angustifolia* mortality rates ranging from 44–50 percent.[218] Some plants killed were completely burnt with only a hole remaining where the trunk had stood.[218] Mortality in the medium to larger arborescent *X. glauca* subsp. *angustifolia* was mainly through trunk fracture.[218] It has been suggested that burning of the leaf skirts exposes the trunk to more rain and sunlight, possibly weakening the trunk and making it more susceptible to fracture.[218] It was found that arborescent *X. glauca* subsp. *angustifolia* that survived fire with severe burn damage to trunks at ground level, would often develop leans, some lying horizontal.[104,218] These horizontal plants had a 44–92 percent mortality rate on burnt sites compared to 29 percent on an unburnt site.[104] After fire, from 3–10 percent of the *X. glauca* subsp. *angustifolia* developed epicormic shoots, this caused by trunk fracture or death of the terminal shoot apex.[104,218] Survival of these epicormic shoots was considered to be dependent on adequate levels of soil moisture.[218] However, these shoots over a 10–12 years post-fire period showed no indication of developing a new trunk and did not flower.[218] It was suggested that it could be more than 20 years before a trunk develops from the epicormic shoot and flowering is resumed.[218] The indication is that fire could impact on *X. glauca* subsp. *angustifolia* up to 20–25 years post-fire.[218]

Xanthorrhoea resinifera were significantly less abundant on sites burnt twice or three times over a three year period compared to sites burnt only once over the same period.[355] Unpublished research by D. Keith and M. Tozer in New South Wales found a considerate number of *X. resinifera* will die immediately after fire, this including adult plants (Figure 9),[323,325] all one-year old seedlings and 61 percent of seedlings aged 2–4 years.[325] The probability of survival for individual plants was also thought to decrease for the first few years following fire because of factors like water stress, disease or stresses associated with starch reserve depletion.[323,325] Both this unpublished study and a Victorian study of *X. glauca* subsp. *angustifolia* (ex *X. australis*),[218] indicate post-fire survival of *Xanthorrhoea* should be studied over time frames of at least 20 years. Population viability assessment modelling was carried out for *X. resinifera* and suggests that within 100 years, mortality from exposure to disease and a mean fire interval of 13 years could lead to approximately an 80 percent reduction in population size (Figure 10).[323,324] For this model the impact on average effective population size (number of breeding plants) was also high with a 65 percent decline predicted.[324] A second model was developed as a best-case scenario with a stable population that was likely to simulate a population that was free from disease.[323] In this best-case scenario model the *X. resinifera* population increased by an average of 5.1 percent over the 100-year simulations (Figure 10),[323] and the effective population size increased by an average of 6.8 percent.[324] This increase in effective population needs to be treated with some caution. As previously mentioned in section **4.7.1.1**, a 100-year simulation may not necessarily distinguish between a stable population and one declining towards extinction in species where life expectancy can significantly exceed 100 years.[364] *Xanthorrhoea resinifera* probably can live significantly longer than 100 years, based on the 300+ year life expectancy of other *Xanthorrhoea*.

Increased flowering after fire has been recorded for *X. australis*,[12,136,155,161,199,290] *X. drummondii*,[194] *X. fulva*,[30,102] *X. glauca*,[102] *X. glauca* subsp. *angustifolia,*[218] *X. gracilis*,[194,345] *X. johnsonii*,[10,90,356] *X. latifolia*,[102] *X. macronema*,[105] *X. minor*,[155] *X. nana*,[343] *X. preissii*[156,194,309,345] and *X. resinifera*.[116] In a New South Wales study, *X. fulva* plants burnt in October 1995 had fully developed inflorescences by August 1995, and had released most seed in the summer of 1995–96 with young seedlings observed by July 1996.[102] This is a period from fire to seedlings of nine months.[102] Fire was found to be non-essential for *X. australis* to develop inflorescences, but it did increase inflorescence production.[12] In the Australian Capital Territory fire increased flowering of *X. australis* in the first year post-fire when burning was conducted in November, February or late September;[12,155] however, burning in May and August had a biphasic impact with little flowering in the first year post-fire but many plants flowering in the second year following the fire.[155] Plants burnt in late September commenced development of inflorescences three months earlier than unburnt controls.[12] This study also looked at ethylene release during burning as a possible trigger for flowering. Unburnt plants treated with ethylene in early October were also found to have a significant increase in flowering compared to the controls, but did not commence flowering earlier.[12] Although burning produced more inflorescences, seed set did not differ between burnt and unburnt plants.[12] For Victorian *X. glauca* subsp. *angustifolia* (ex *X. australis*), flowering post-fire showed distinct pulses that were related to post-fire effects, but also occurred in the absence of fire.[218] The probability of *X. resinifera* flowering following fire was found to be highest two years post-fire.[323]

Apart from ethylene gas being a possible trigger for flowering in *Xanthorrhoea*, other factors such as leaf removal (e.g. by clipping or burning), fire frequency and seasonal triggers may play a role in the initiation of flowering in *Xanthorrhoea*.[102] Whether flowering triggers are similar for all *Xanthorrhoea* species is unknown.[102] In *X. fulva* flowering was stimulated by fire, but the proportion flowering varied with time since the previous fire.[102] A fire interval of 3.75–5.25 years produced significantly more flowering in *X. fulva* than a longer fire interval of 9.3–16.9 years.[102] Clipping leaves to ground level on trunkless *X. australis* in South Australia did not induce flowering,[136] while in other studies clipping induced flowering in *X. fulva* and *X. australis*.[12,102] It is reported that frequent fires that induce repeated flowering may deplete food reserves to the point where a fire will not trigger flowering.[219] It is also reported that some species growing in quite moist soils can flower in season without fire, often synchronously.[219]

Fire can influence *Xanthorrhoea* flowering in other ways. A study of *X. preissii* in Western Australia found the mean flower spike weight following burning in spring (1.19kg) was significantly greater than for plants burnt in autumn (0.78kg).[152] In a further *X. preissii* study, plants in 14 populations that were burnt in either spring, summer or autumn, showed no relationship between height (range 0.1 to just over 2m) and inflorescence length, spike length, fruit density and scape width.[239] However, the percentage of plants flowering following these burns increased with plant height.[239] The study found that the season of the burn did not affect inflorescence length, but mean flower spike length and width and scape thickness were significantly less following spring burns compared to flowering following summer and autumn burns.[239] The reduction in these inflorescence dimensions following spring burns did not translate into a reduction in the total number of fruits set per spike.[239] Season of burn did however affect the total number of plants flowering in the 0.5–1.0m height class and thus the total number of fruits produced by plants in this height class.[239] This resulted in summer-burnt populations producing 3.2 times more fruits than autumn-burnt populations and about five times more than spring-burnt populations.[239] The reasons for the differences in flowering percentage and fruit production following burns in summer, spring and autumn are unknown.[239] It is clear further research is required on the triggers for flowering, especially the role of fire.

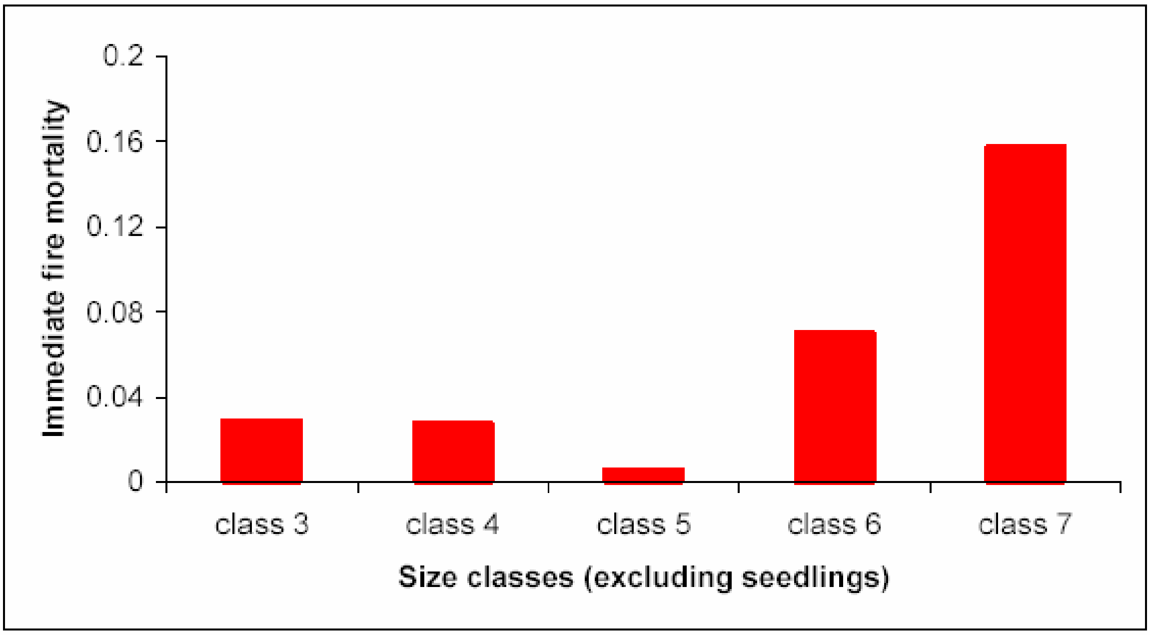


Figure 9: Immediate post-fire mortality of juvenile, sub-adult and adult *X. resinifera*.[326] Expressed as a proportion of plants in each age class.

Class 3: Plants 21–30 years old with <16 leaves and the caudex below ground.
Class 4: Plants with 16–50 leaves and caudex below ground.
Class 5: Plants with >50 leaves and caudex below ground.
Class 6: Plants with caudex ≤10cm above ground.
Class 7: Plants with caudex >10cm above ground.

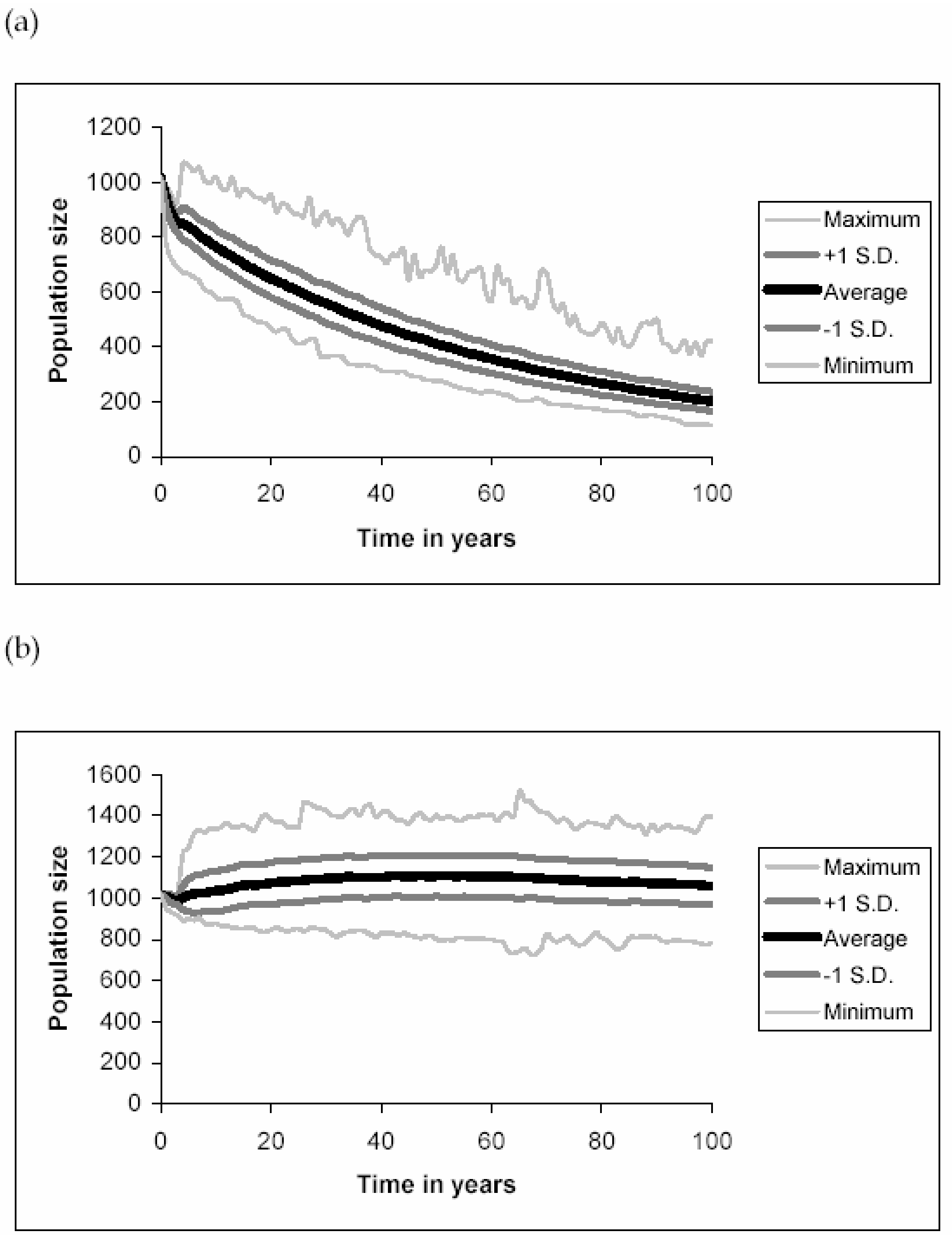


Figure 10: *Xanthorrhoea resinifera* population trajectory summary for the (a) base model [exposure to fire and disease] and (b) the best-case scenario model [exposure to fire but disease free].[327]

Time of seedling emergence after fire should indicate whether viable *Xanthorrhoea* seeds were on the ground at the time of the fire, and if so, that these seeds can survive fire. However, seedling emergence post-fire indicates no pre-fire fallen seed is associated with post-fire seed germination. Heat treatment kills *X. gracilis* and *X. preissii* seeds,[193,295] indicating they are not fire tolerant. In these two *Xanthorrhoea* species, seeds produced following a fire are released in an environment where another burn is not imminent, so there is no adaptive significance to tolerate high temperature.[193] *Xanthorrhoea* seeds are dark,[227] and this too may be a post-fire adaptation, as seeds produced from a post-fire flowering should be camouflaged better from seed predators when they fall on a post-fire soil surface.[295] *Xanthorrhoea gracilis* and *X. preissii* normally recover after fire by resprouting, with seedlings rarely seen in the first year following the fire.[193] This indicates *Xanthorrhoea* seeds on the ground at the time of the fire are killed. There was an absence of *X. australis* seedlings up to 23 months post-fire in heathland on Dark Island in South Australia.[136] Prior to this burn the heath had not been burnt for 6–7 years.[136] *Xanthorrhoea johnsonii* seedlings did not appear until the second year after a September burn in coastal heathland in northern New South Wales.[242] Prior to this September burn, the study sites had been unburnt for 9–16 years.[242]

In the northern New South Wales heathland study of *X. johnsonii*, high numbers of seedlings were produced post-fire, but three years after the fire only round 40 percent remained.[242] Field trial experiments where *X. glauca* subsp. *angustifolia* seeds were sown both below and on the surface of either heavily or lightly burnt soils, found germination was best for seed sown below the surface.[138] Very few of the surface-sown seeds germinated and survived.[138] In a Victorian study, *X. glauca* subsp. *angustifolia* seedling recruitment over a two year period following fire was significantly lower on burnt areas with little ground cover in comparison to sites unburnt for at least 15 years where seedlings were protected by understorey vegetation.[104] Post-fire seedling survival of *X. resinifera* was found to vary considerably between and within a series of New South Wales study sites.[323,325] Fire could result in significant seedling recruitment in *X. resinifera*, but high background mortality coupled with immediate post-fire deaths (Figure 9) can lead to a lack of recruitment to the reproductive stages of the plant.[323,325] Most *X. resinifera* seedling loss was in the first 10 years following germination.[323]

4.7.4 Clearing

No published information was found on the impact of clearing on Queensland *Xanthorrhoea* populations. However, in Queensland current clearing practices on privately managed lands still result in the loss of *Xanthorrhoea* plants from wild populations. The level of salvage harvesting still occurring in Queensland is evidence of this. For instance, in the 2003–4 Queensland plant harvest season over 37 389 *Xanthorrhoea* plants were reported to have been salvage-harvested.[177] Significant clearing has also occurred in a number of threatened Queensland regional ecosystems where two of the main harvested *Xanthorrhoea* species occur (see sections **2.7.4** and **3.7.4**). In South Australia it was reported as far back as 1917 that "thousands of acres of South Australian grass tree country had already been cleared".[249] It was reported in 1966 that clearing and cultivation was the probable cause of the scarcity in northern Tasmania of what was then called *X. minor*.[320] Back in 1857 prior to clearing and cultivation, it was reported by botanists that this *Xanthorrhoea* occurred over large areas of northern Tasmania.[320]

Vegetation clearing may not always kill all *Xanthorrhoea* plants. Two non-arborescent species, *X. fulva and X. macronema*, are known to survive regular slashing to ground level on fire breaks in two south-east Queensland State forests.[328] Although cutting off the arborescent stems of *Xanthorrhoea* below all existing terminal shoots will often kill the plant, this not always the case.[157] In *X. australis*, cutting the arborescent stem just above ground level can result in adventitious shoots.[157] Adventitious roots can also grow from stem injuries in *X. australis*.[157]

4.7.5 Timber harvesting

No information was found on the impact of timber harvesting and associated practices on *Xanthorrhoea*.

4.7.6 Other

Jarrah forest areas in Western Australia with *X. gracilis* and *X. preissii* in the understorey are mined for bauxite by Alcoa.[240,272] Mining involves removal of the overburden including topsoil.[272] Currently about 500–800ha of jarrah forest is mined and restored annually.[240] The current mine rehabilitation program includes re-seeding with a mix of native species that includes *X. gracilis* and *X. preissii*.[131,240] Re-establishment of both *Xanthorrhoea* species is considered a priority in Alcoa's bauxite mining restoration program.[240] On sand mining sites near Eneabba in Western Australia rehabilitation includes re-seeding with a native seed mix that includes *X. drummondii*.[137]

4.8.0 Threats, population health, conservation and management

Of the 28 recognized *Xanthorrhoea* species in Australia,[143] two are currently listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) as threatened.[179] *Xanthorrhoea bracteata* is listed as endangered and *X. arenaria* as vulnerable.[179] Both species only occur in Tasmania,[143,204] which lists them as vulnerable.[185,204] The two species have restricted distributions and are threatened by the root rot fungus *Phytophthora cinnamomi*.[204,264,265,269] None of Queensland's 14 *Xanthorrhoea* taxa (includes sub-species), are currently listed as rare or threatened under Queensland legislation.[180] No *Xanthorrhoea* are currently listed as endangered or vulnerable in New South Wales.[181] *Xanthorrhoea caespitosa* and *X. semiplana* subsp. *semiplana* are listed as rare in Victoria.[182] In South Australia *X. minor* subsp. *lutea* is listed as endangered, *X. thorntonii* as rare,[183] and *X. semiplana* has been proposed for listing as rare.[234] In Western Australia no *Xanthorrhoea* are listed as threatened,[184] but *X. brevistyla* is considered rare.[241]

4.8.1 Animal threats to *Xanthorrhoea*

In Western Australia, the Port Lincoln parrot *Barnardius zonarius semitorquatus* browses on the leaves of *X. preissii*.[147] The parrot chops and sheds the leaves and this leaf chaff accumulates on and between the damaged leaves on the plant's crown.[147] The accumulated chaff on the crown becomes mouldy and rotten, this rotting chaff attracting large number of insects.[147] Once a *X. preissii* has 90 percent or more of its leaves damaged, the Port Lincoln parrot will continue to feed annually on the crown until the plant finally dies, with anecdotal evidence suggesting death takes 4 to 7 years.[147] Death rates can be significant (23.6 percent of plants on survey sites with high levels of parrot damage).[147] As there is evidence of an increase in Port Lincoln parrot numbers in the southwest of Western Australia, the deaths of *X. preissii* caused by the parrot may exceed past levels and therefore may constitute a threat to the grasstree.[147] This is further exacerbated by the fragmentation and loss of *X. preissii* by clearing for agriculture within this region.[147]

Grazing/browsing by other animals may also be a threat to *Xanthorrhoea* populations. It is reported that persistent heavy grazing of very small *X. australis* can be a "potent mortality factor",[155] but the author fails to identify whether this is grazing by stock or by other animals (e.g. rabbits, macropods). Based on observations, it was reported that *Xanthorrhoea* regeneration does not occur in heavily grazed areas, although effect of moderate grazing was considered as probably inconsequential.[264] The rarity or lack of *Xanthorrhea* seedlings in Western Australian jarrah forest is believed to be because of heavy kangaroo grazing.[240] Grazing by what is believed to be western grey kangaroos *Macropus fuliginosus*, reduced seedling survival and growth in *X. gracilis* and *X. preissii* on restored mining land in Western Australia.[240] However, on this kangaroo-grazed restored mining land, *X. gracilis* and *X. preissii* seedling growth was facilitated where they were provided with cover by other plant species.[240] Rabbit grazing was thought to be probably responsible for a reduction in recruitment of *X. glauca* subsp. *angustifolia* in the Warby Range, Victoria, although kangaroos also graze in the area.[104] The impact of macropod grazing on *Xanthorrhoea* seedling survival and growth needs to be investigated further, especially in eastern Australia. A Victorian study of *X. glauca* subsp. *angustifolia* has already found that in some years almost 80 percent of the developing inflorescences on some of the sites were grazed by herbivores, resulting in destruction of the inflorescence or greatly reduced seed production.[218] In south-east Queensland the inflorescences of *X. johnsonii* can be destroyed or broken by possums, with up to 23 percent of the flower spikes damaged on some sites.[90]

4.8.2 Fire threat to *Xanthorrhoea*

Fire regimes may threaten the viability of *Xanthorrhoea* populations, but what constitutes an optimum fire regime is still unclear. Various fire-free periods have been suggested as appropriate for *Xanthorrhoea*. Population viability analysis modelling of *X. resinifera* in New South Wales indicates that the optimum minimum fire interval for populations free from disease is between 8–13 years.[323] For maximum *X. australis* seed production in the Australian Capital Territory, it was recommended plants were burnt in summer at six-year intervals.[12] It was noted that long fire intervals were unlikely to lead to loss of *X. australis*, since sporadic flowering occurs in the absence of fire and individual plants may be long lived.[12] However, for *X. australis* in a Victorian study, it was thought current fire exclusion policies were likely to see forest populations of *X. australis* become extinct, while on heathland sites they would probably survive.[199] In another Victorian study there was an indication that some *X. glauca* subsp. *angustifolia* plants could still be recovering from the effects of fire up to 20–25 years post-fire.[218] Research into *X. fulva* suggests a minimal fire-free interval of three years was required for seedlings to become fire resistant.[102] *Xanthorrhoea resinifera* seedlings up to one year old do not survive fire and 61 percent of seedlings 2–4 years old are also immediately killed by fire.[323,325] For *X.*

thorntonii, which is listed as rare in South Australia,[183] a high fire frequency was seen as a long-term threat.[264] In Tasmania inappropriate fire regimes were reported to be detrimental to the vulnerable *X. bracteata*, as was inappropriate fire intervals for the vulnerable *X. arenaria*.[204] Although inappropriate fire management was a concern for these two Tasmanian *Xanthorrhoea*, no research information was found on what their optimum fire regimes should be.

In arborescent *Xanthorrhoea*, black bands can be revealed on the trunks by grinding back to the persistent leafbases.[154] These bands correspond to when plants were burnt and together with lighter coloured seasonal growth bands have been used to determine fire history, in some cases dating back some 250 years.[154] The technique shows that for south-western Australia fire frequency was 3–5 years in the 80 years prior to European settlement and the first 40 years post-settlement.[154] Currently this band technique is being tried out in Queensland to determine fire histories on selected woodland sites.[279] However, problems are being experienced in using the technique to distinguish seasonal growth bands on Queensland *Xanthorrhoea* so far sampled.[280] Even if pre-European fire intervals can be determined in Queensland there is no assurance that these intervals were optimum for *Xanthorrhoea*.

The impact of fire maybe linked to other factors that effect population recruitment. For example, fire mortality by repeated burning of non-reproductive *X. glauca* subsp. *angustifolia* with small aerial stems, coupled with rabbit grazing, may ultimately lead to the extinction of populations through lack of adult recruitment.[104] Insect attack may also be a threat to maintenance of *Xanthorrhoea* populations. The larvae of the moth *Meyriccia latro* can destroy entire seed sets on individual plants,[90,152,155] or stunt or twist inflorescences.[241] For *X. australis*, insect larvae attack following post-fire flowering on Dark Island in South Australia resulted in no seedlings being established.[161] However, the relationship between *M. latro* and *Xanthorrhoea* needs further investigation as the relationship is possibly symbiotic because pollination and seed production as a result of the moth visiting the flowers may exceed seed loss by the larvae.[241]

4.8.3 *Phytophthora* threat to *Xanthorrhoea*

A confirmed threat to *Xanthorrhoea* is the root rot/dieback fungus *Phytophthora cinnamomi*. The fungus is found in all Australian States and Territories.[218] It has been in Australia at least 75 years and probably over 100 years, the fungus first recorded as a disease of pineapple plants in Queensland.[281,284] Including *Xanthorrhoea*, there are over 1000 plant species known to host *P. cinnamomi* in Australia,[245] but it is suspected the number of susceptible species is much higher.[218] A number of *Xanthorrhoea* species have been shown to be either susceptible or highly susceptible to the fungus and include *X. arenaria*,[186,204] *X. australis*,[175,176,186,189,245,247,263,268,270,277,278,289] *X. bracteata*,[204,269] *X. glauca* subsp *augustifolia*,[218,220] *X. preissii*,[190,264] *X. platyphylla*,[191,264] *X. quadrangulata*,[212] *X. semiplana*[212] and *X. semiplana* subsp. *tateana*.[212] The fungus is considered probably the biggest threat to *Xanthorrhoea* in Tasmania, Victoria and Western Australia, where in badly infected areas *Xanthorrhoea* are undergoing massive declines.[264] One view is that all *Xanthorrhoea* are susceptible to the fungus and it is a contributing factor in the death of many transplanted xanthorrhoeas.[219] A second view is that there is no evidence to suggest all *Xanthorrhoea* are susceptible to the fungus.[339] For instance, in Queensland the fungus has not been isolated from *Xanthorrhoea* and no significant *Xanthorrhoea* dieback has been observed that could be linked to *P. cinnamomi*.[338,339,349] This is in spite of the fungus being present in Queensland, where it does cause rainforest dieback and pineapple root rot.[281,336,337] As far back as 1970 *P. cinnamomi* has been isolated from coastal lowland vegetation in south-east Queensland.[352] Species reported to be affected by the fungus in this coastal lowland vegetation did not include *Xanthorrhoea*,[352] although *Xanthorrhoea* species such as *X. fulva* , *X. macronema*, *X. johnsonii* and *X. latifolia* can occur in coastal lowland vegetation.[6,14,17,18,143]

Phytophthora cinnamomi initially infects the fine roots of susceptible plants causing necrotic lesions that lead to invasion of the vascular tissue and eventual death of the plant.[245] In *Xanthorrhoea* the pathogen can infect the apical meristem.[270] *P. cinnamomi* has several means of dispersal and a flexible life cycle, and once in soil and roots is difficult to control.[278] Zoospores are dispersed in water or wet soil, chlamydospores in gravel and soil and mycelium can persist in soil aggregates.[278] It is believed that the motile zoospores are chiefly responsible for the long-distance spread of the fungus.[289] The rate of spread of *P. cinnamomi* varies considerably, from as little as around 1m/year,[245,246] to as much as 400m/year downhill with free water flow[246]. In Kinglake National Park in Victoria where *P. cinnamomi* can be active year-round, its activity had a winter and summer maxima.[176] Healthy *X. australis* on this site once infected took an average of about 24 weeks for their foliage to yellow, brown off and die.[176] Others report that *X. australis* usually die within 6–12 months of the appearance of symptoms.[289] The first obvious symptom is usually yellow patches on the leaves.[236] The majority of *X. australis* that initially showed chlorosis of the leaves on study sites in the eastern Otway Ranges of Victoria, were dead within 12 months.[245] On study sites in the Grampians and Kinglake National Parks in Victoria, initial infestation of *X. australis* caused very high death rates.[175,176] However, on one of the three infested study sites in the Grampians National Park, there has been significant regeneration of *X. australis* over the last five years of a 24-year monitoring period since infestation.[175] In this five year period *P. cinnamomi* levels in the soil and the roots of living plants dropped to low levels, which was thought to be in part to the driest weather on record.[175] *Phytopthora cinnamomi* zoospore production and dispersal is poor in dry conditions.[175] On another Victorian study site, *P. cinnamomi* levels have also dropped after initial infestation, and a number of other reasons were given for the decline of the fungus.[176]

Although there had been recovery of *X. australis* on one of the three infested study sites in the Grampians National Park,[175] and on some infested study sites elsewhere in Victoria,[175,178] the investigators in the Grampians study felt there was no strong evidence that this trend in recovery would be sustained in the future.[175] Recovery of *X. australis* from *P. cinnamomi* infestation in the Brisbane Ranges, Victoria was from germination of new plants, the result of seeding from scattered mature plants that survived the initial infestation of the fungus.[178] The regeneration plants may still succumb to *P. cinnamomi* if the fungus increases coincident with increasing susceptible root mass.[289] Infestation will be promoted when there is sufficient water and suitable temperatures for zoospore production and dispersal.[289]

The impact of *P. cinnamomi* is a consideration in the rehabilitation of Western Australian mine sites with species like *Xanthorrhoea* that are susceptible to the fungus. Important to rehabilitation and re-establishment of high flora species richness on Western Australian open–cut bauxite mining sites, is re-seeding with key local native forest species such as *X. preissii*.[192] Rehabilitation of mineral sand mining sites near Eneabba in Western Australia include *X. drummondii* seeds in the re-establishment seed mix.[137] The impact of dieback disease caused by *P. cinnamomi* on key mine rehabilitation species such as *X. preissii* has not been fully determined, but early indications are that high species richness can still be obtained despite *Phytophthora* being present.[192] Fire has been recorded killing *P. cinnamomi* to a depth of 20–25cm.[247] It has been suggested that fire can be used as a tool to reduce the levels of *P. cinnamomi* infestations and to encourage recovery of *Xanthorrhoea* from the fungus through the establishment of new plants following post-fire flowering.[246] Control burning is also suggested as a tool to stimulate regeneration in *X. australis* once the inoculum level of *P. cinnamomi* has declined to a sufficiently low level to allow survival.[278]

4.8.4 Clearing threat to *Xanthorrhoea*

No information was found that quantifies the threat of current and past land clearing on *Xanthorrhoea* populations in Queensland. However, a significant proportion of the Queensland regional ecosystems in which *X. johnsonii* and *X. latifolia* subsp. *latifolia* occur are listed as “endangered” or “of concern” because of past clearing. For *X. johnsonii* about one-third of the 112 regional ecosystems in which it occurs have a biodiversity or vegetation management status that is either “endangered” or “of concern”, while for *X. latifolia* subsp. *latifolia* over half of the 54 regional ecosystems in which it occurs are “endangered” or “of concern”. Regional ecosystems listed as “endangered” have been over 90 percent cleared and “of concern” regional ecosystems have been 70–90 percent cleared.[215] Although both *Xanthorrhoea* species occur in significantly cleared regional ecosystems, the extent to which clearing has reduced *Xanthorrhoea* populations in these regional ecosystems is not known. However, it is not unreasonable to surmise that a significant proportion of *Xanthorrhoea* populations have been lost there by clearing. The threat of clearing to *Xanthorrhea* populations elsewhere in Australia has also been poorly quantified or documented. However, jarrah forest where *Xanthorrhoea* occurs has been cleared for bauxite mining since 1963.[272] Clearing rates were reported in 1994 and 2001 to be approximately 450ha annually,[192,272] but by 2004 they were reported to have increased to 500–800ha annually.[240] Without a successful mine site re-vegetation program that includes *Xanthorrhoea*, the long-term impact of clearing associated with bauxite mining could be significant.

Current levels of salvage harvesting of *Xanthorrhoea* in Queensland and other States like Victoria and Western Australia,[178,207,213] indicates loss is still occurring to wild populations due to clearing. Although salvage harvesting currently does not occur in South Australia,[322] as far back as 1917 it was reported that “thousands of acres” of South Australian grasstree country had already been cleared.[249] Clearing is also reported as a probable impact on *Xanthorrhoea* in northern Tasmania.[320]

4.8.5 Harvesting threat to *Xanthorrhoea* and associated animals

The level of potential threat to *Xanthorrhoea* from harvesting varies from State to State in Australia. Because no official take of live *Xanthorrhoea* is currently allowed in South Australia,[322] the threat from harvesting is probably minimal. Salvage harvesting in Victoria is currently considered to be very limited.[207] There is still a low level of official harvest of *Xanthorrhoea* foliage and stems in Victoria, but it is suspected there is a significant illegal trade.[208] The illegal harvest of whole plants from public land in Victoria was a problem as far back as around 1990.[228] Past and current levels of illegal *Xanthorrhoea* harvest in Queensland are unknown, so assessing the threat from this activity is not possible. However, a telephone interview survey of native plant sellers across Australia in 1997, found Queensland sellers reluctant to provide information on wild harvesting of long-lived native plants.[214] This reluctance to provide information gave the telephone interviewers the impression that there may be some illegal harvesting issues in the State.[214] In Western Australia there is anecdotal evidence of illegal *Xanthorrhoea* harvest, mainly from the metropolitan areas around Perth.[213]

Xanthorrhoea plants taken and offered for sale in Queensland, New South Wales and Victoria require tagging.[205,208260] Propagated *xanthorrhoeas* do not require tags in New South Wales.[260] There is no tagging system for *xanthorrhoeas* taken in Western Australia and Tasmania,[209,213] which can make detection difficult for illegally taken plants that are moved across State borders.[208] Currently there is no restriction on the take of non-threatened *Xanthorrhoea* species from private land in Tasmania.[209] In Tasmania, *Xanthorrhoea* foliage is officially harvested from public land (forestry and crown land tenure),[209] but there is currently no management plan for this harvesting.[210] Commercial licences for the take of whole *Xanthorrhoea* plants on reserved land in Tasmania must meet management conditions prepared to satisfy federal government requirements.[210] The management plan under which *Xanthorrhoea* are harvested in New South Wales is currently under review.[260]

There was no research data found on survivorship of harvested whole plants. It is however reported that most transplanted grasstrees live no more than three to four years.[219] Plants may initially survive the massive root loss and disturbance from transplant because of considerable reserves of food stored in their trunks, but when these reserves are exhausted the plant dies.[219] *Xanthorrhoea thorntonii* reportedly does not transplant readily.[231] Some Melbourne nurseries have also reported ceasing the selling of *Xanthorrhoea* because they could not keep transplanted plants alive.[228] It has been suggested that the way to eliminate the need for wild harvested whole plants in the nursery trade is to encourage propagation of *Xanthorrhoea* from seed, as fast growing *Xanthorrhoea* species can develop noticeable trunks in 10 to 15 years,[219] and many species will flower after only five or six years.[264] *Xanthorrhoea glauca* is capable of flowering and developing a large and attractive spray of foliage in five or less five years.[262] *Xanthorrhoea johnsonii* can also be grown in nursery conditions from seed to flowering stage in about 5–6 years.[261] Propagation from seed has already been adopted by some commercial plant growers.[262] Although propagation from seed is an option to reduce pressure to harvest whole plants from the wild and ease illegal harvest, it would require sustainable management of seed harvest.

What constitutes ecologically sustainable *Xanthorrhoea* foliage harvest is still largely undetermined both in Queensland and elsewhere in Australia. *Xanthorrhoea* foliage became a popular green filler in floral displays in the 1980s,[228] and its harvest in Queensland for this purpose is substantial. Total tonnage of *Xanthorrhoea* leaves harvested in the 2003–4 harvest season by the two commercial harvesters currently dominating the Queensland industry was just over 207 tonnes.[202,274] Harvesting in Queensland is conducted under a code of practice outlined in the EPA conservation and management plan for protected plants,[205] and the main foliage harvester has developed its own code of practice for foliage harvest and has set up a number of *Xanthorrhoea* harvest monitoring plots.[328] In spite of these measures to ensure ecological sustainability of foliage harvest, the impact of harvesting on populations of *X. johnsonii*, *X. latifolia* and *X. glauca* is largely unknown and nothing is known of the impact of foliage harvest on animals associated with *Xanthorrhoea*. In part this is because EPA monitoring guidelines under which monitoring plots have been established, are scientifically and statistically inadequate and do not address monitoring impact on animals associated with *Xanthorrhoea*. In part this is because of poor choice by the harvester as to which plant variables they measure. Other problems with the data are caused by possible measurement bias where the harvesters have used different personnel to take field measurements.[334,350] It means field data and analyses thereof are at best limited in providing answers on the threat foliage harvest has on sustainability of *Xanthorrhoea* populations.

There is also limited data on the impact of *Xanthorrhoea* foliage harvest from elsewhere in Australia. For the Western Australian grasstree *X. preissii*, a study simulated fire response by foliage clipping.[152] The study found a strong capacity by *X. preissii* to recover from leaf clipping, even after clipping every month for 16 months.[152] However, starch reserves were depleted in the desmium of clipped plants, and at one of two study sites, even a single clipping was sufficient to measurably reduce starch reserves.[152] Regular long-term clipping of individual plants may even cause death. *Xanthorrhoea preissii* are killed by Port Lincoln parrots *Barnardius zonarius semitorquatus* through repeated browsing (clipping and shredding) of the leaves.[147] It is unclear whether deaths are a direct result of clipping or through a combination of clipping and rotting leaf chaff accumulating on top of the plant. For more detail on Port Lincoln parrot damage to *Xanthorrhoea* see section **4.8.1** of this report.

More than one approach has been suggested to determine the effects of repeated foliage harvest on growth and survival of *Xanthorrhoea*. They include the measurement of growth rate for regenerating foliage under different harvest regimes or by taking photosynthetic measurements and relating these back to whole plant growth.[266] From a limited trial where photosynthetic measurements were related back to plant growth in *X. australis* and *X. johnsonii*, it was concluded that harvesting of foliage could be carried out without necessarily producing any long term effects on the plant.[266] However, the same study also recommended that if foliage harvest was frequent or on a large scale that further study of the species in question should be carried out.[266]

There is also some evidence to suggest that *Xanthorrhoea* foliage clipping can impact on the initiation and timing of flowering, and on inflorescence biomass and seed production (see also section **4.7.1.1** of this report).[12,55,102,152,155] Whether these impacts have a significant medium to long-term negative effect on wild *Xanthorrhoea* populations is unknown, although there are indications that reproductive aspects[152] of their lifecycle maybe significantly affected. Animal grazing or fire immediately after *Xanthorrhoea* complete their reproductive cycle are also seen as potential threats because stored resources in the plant are depleted.[241] Grazing and fire both remove foliage and their impact maybe analogous to harvesting foliage.

As highlighted, monitoring to date provides no answers on the impact of foliage harvest on the many animals associated with *Xanthorrhoea* (See Tables 8 and 9). Monitoring this impact and further studies on the impact of harvesting on the plant should be considered a priority, and until addressed, the verdict on the impact of foliage harvest on *Xanthorrhoea* should remain out.

4.8.6 Other threats to *Xanthorrhoea*

There is one other possible threat that needs highlighting. Phosphorous poisoning has been identified as a possible long-term threat to *Xanthorrhoea*,[264] although no published data was found evaluating the threat. The main source of phosphorous is dust or run-off from agricultural top-dressing.[264]

5.0 Conclusions and recommendations

The main aim of this report was to examine whether current knowledge of *Xanthorrhoea* would allow conclusions to be made about the ecological sustainability of harvesting from the wild in Queensland. To help reach some meaningful recommendations required a review of *Xanthorrhoea* distribution, abundance, habitat, ecology, the level of harvest and the threat that harvesting, land management and other factors might pose. *Xanthorrhoea johnsonii* and *X. latifolia* subsp. *latifolia* are the two main grasstree species harvested in Queensland. Harvesting has mainly been for whole plants and foliage, but dry inflorescences and occasionally seed have also been taken.

Management of the take of whole *Xanthorrhoea* plants (salvage and non-salvage) needs a sound scientific base. To make informed management decisions on whether the take of *Xanthorrhoea* plants is sustainable and should continue in Queensland requires knowledge of population sizes, genetics, demographics, health and protection on conservation reserves and elsewhere. Minimum viable *Xanthorrhoea* populations may need to be around 500 breeding plants to maintain long-term genetic variability. This would equate to 2500 plants if 80 percent of a population consisted of immature plants. This does not take into account what a minimum population size should be to avoid extinction based on normal demographic and environmental stochasticity or the impact of catastrophic events such as severe drought or wildfire.

Currently there is no information, reasonable estimate or otherwise, of population sizes for *Xanthorrhoea* species currently taken under permit in Queensland. It is known that *X. johnsonii* is the broadest ranging *Xanthorrhoea* species in Queensland, occurring over much of the eastern half of the State. *Xanthorrhoea latifolia* subsp. *latifolia* has a distribution in eastern Queensland that is more patchy and coastal. It is also known that a significant proportion of the Queensland regional ecosystems in which the two *Xanthorrhoea* species are known to occur are listed as "endangered" or "of concern" with 70 percent or more of these ecosystems cleared. This indicates both *Xanthorrhoea* have probably already been significantly affected by clearing in spite of them still being common to abundant in some localities. Although there is no knowledge of current population sizes for the two *Xanthorrhoea*, there is concern that the level of non-salvage harvest of whole plants from the wild may be a significant proportion of remaining *Xanthorrhoea* populations. This raises concerns about the ecological sustainability of continuing to harvest whole plants.

Another concern is that there is no state-wide information on the genetics of *Xanthorrhoea* populations. The three main *Xanthorrhoea* species harvested in Queensland vary in physical attributes across their range, which may indicate some populations may be genetically distinct. Surveys are required to ascertain the taxonomic status of all *Xanthorrhoea* populations in Queensland, especially *X. johnsonii*, *X. latifolia* subsp. *latifolia and X. glauca*. If species like *X. johnsonii* and *X. latifolia* subsp. *latifolia* include more than one taxon it is possible that harvesting could already be threatening one or more of these undescribed taxa.

There is currently no demographic information (e.g. age structure) of *Xanthorrhoea* populations harvested in Queensland. This knowledge gap is not helped when harvesters taking whole plants are not required to provide detailed information on *Xanthorrhoea* harvested. No detailed information is provided on the size of plants taken and the demographics and size of populations harvested. This information is important to estimate the proportion of wild plants taken from regional populations and allow proper assessment of the ecological sustainability of harvesting. Population viability modelling of *X. resinifera* in New South Wales that included harvest simulations, suggests harvesting of 100 adult plants from an initial population of 467 adult plants (= 21 percent of initial population), could lead to an average drop of up to 27 percent in the number of adult plants within 100 years. The harvest simulations found least impact when harvesting was conducted at the rate of one plant per year for 100 years compared to a single harvest of 100 plants at the 50-year mark. This type of modelling would be useful for investigating optimal levels of sustainable *Xanthorrhoea* harvest in Queensland, preferably over simulations times greater than 100 years.

Although significant numbers of *Xanthorrhoea* plants are taken annually from the wild under permit in Queensland, there is also no information on survivorship of these plants once harvested. If anecdotal information is correct, many arborescent *Xanthorrhoea* taken from the wild will die within two to three years because of the transplant process. If true, then this may have implications as to whether harvest of whole plants should even continue, especially non-salvage harvest.

As well as whole plant harvest, a significant amount of *Xanthorrhoea* foliage is harvested annually and used as floral filler in the flower trade. There is some concern about the ecological sustainability of foliage harvest, especially as reporting detail and monitoring programs assessing impact are not adequate. Reporting of the amount of *Xanthorrhoea* foliage harvested in Queensland relies heavily on commercial operators accurately documenting foliage take.[202] If foliage take is to continue then government monitoring of foliage harvest from the wild may need to be upgraded, especially in regard to harvest frequency, season of harvest and percentage take from individual plants and populations. In Queensland there is still only limited monitoring of the impact of foliage harvest on *Xanthorrhoea* plant health and to date this monitoring is conducted on monitoring plots set up and measured by commercial operators. Data from these monitoring plots is at best limited and in some instances questionable because of small sample sizes, inappropriate measurement variables and possibly inadequate precision and accuracy of measurements. The data cannot fully assess impact of foliage harvest on plant growth or on the reproductive output of *Xanthorrhoea* populations being harvested. Consideration should be given to establishing a monitoring program funded by harvesters but conducted independent of them. Although there are government guidelines on where and how foliage maybe harvested on a plant, and how often and how much can be harvested, the scientific basis for these guidelines is at best limited. Minimum sample sizes recommended in government guidelines for foliage monitoring plots are statistically inadequate. A review is required of the scientific adequacy of current government guidelines for *Xanthorrhoea* monitoring and where necessary new monitoring guidelines developed.

Apart from the limited data from the foliage monitoring plots, studies examining the impact of grazing and fire on *Xanthorrhoea* species provide further information relevant to the impact of foliage harvest. One study where foliage clipping was a treatment, found even a single clipping caused a measurable drop in starch reserves within the plant. However, *X. preissii* showed a strong capacity to recover from clipping, even when clipped once a month for 16 months. However, there is little information on the impact of regular, longer-term clipping. Such longer-term foliage clipping of *X. preissii* by parrots does kill plants, but it is unclear if this is caused by the decay of clipped foliage fragments on the growing tip of the plant and/or the depletion of starch reserves. There is already evidence to suggest that foliage clipping can impact on the initiation and timing of flowering, and on inflorescence biomass and seed production. Whether these impacts have a significant medium to long-term deleterious effect on wild *Xanthorrhoea* populations is unknown, although there are indications that reproductive aspects of their lifecycle may be significantly affected. Further research is required to clearly demonstrate that foliage harvest is not detrimental to *Xanthorrhoea* populations.

If *Xanthorrhoea* foliage, inflorescence and whole plant harvest is to continue in Queensland, then research is also required on their impact on associated animals. The harvest of *Xanthorrhoea* (whole plants or parts) not only can impact on the long-term viability of *Xanthorrhoea* populations, but can also impact on associated animals. Over 315 invertebrate and about 100 vertebrate species have been recorded in association with *Xanthorrhoea* Australia-wide. For most of these associated animals there is little understanding of the importance of *Xanthorrhoea* to their survival and population health. However, it would be surprising if *Xanthorrhoea* were not critical to a number of these associated species. Australia-wide at least 22 species of birds, 8 smaller marsupial species (all threatened or rare in one or more Australian State), one endangered native rodent and one reptile have been recorded nesting/living in/under the skirts of dead foliage on *Xanthorrhoea*. Regular clipping has the potential to prevent development of the skirt of dead leaves that these 32 species use. Over 35 invertebrate species are known to either feed on the leaves or have been recorded amongst or on the foliage. What impact regular clipping has on these invertebrates is unknown, but could be significant, especially if large proportions of any given population of *Xanthorrhoea* are frequently clipped.

The harvest of whole *Xanthorrhoea* plants or their inflorescences may also cause loss of animal food, nesting and refuge habitat, especially for some animals of conservation concern. One *Anonychomyrma* ant species sometimes uses *Xanthorrhoea* as a nest site, this species a symbiotic attendant ant to the larvae of the endangered bulloak jewel butterfly *Hypochrysops piceatus* in Queensland. The flowers of *X. johnsonii* are an important source of pollen and nectar for the endangered mahogany glider *Petaurus gracilis* in north Queensland. The crowns of *Xanthorrhoea* are considered important refuge habitat for invertebrates after severe fires. There is concern that if harvesting of dry *Xanthorrhoea* inflorescences is allowed prior to seed fall that there could be an impact on seedling recruitment as well as the animals that feed on the seed. Rodents and at least eight bird species have been recorded feeding on the seed. Even after seed fall the dry flower stems (scapes) are tunnelled by at least 14 species of native bees. Old *Xanthorrhoea* flower stems are important to *Xylocopa aeratus* and a number of other native bees as breeding and/or refuge sites. Loss of *Xanthorrhoea* or their flower stems could have a serious impact on the breeding success of invertebrates such as *Xylocopa*. Already habitat destruction and loss of nesting sites has been identified as the greatest threat to native bees such as *Xylocopa aeratus*. Extensive clearing for agriculture and property development is believed to be probably responsible for the dramatic decline in the distribution of native bees in the genus *Xylocopa*, with *X. aeratus* already extinct on mainland South Australia. Apart from native bees, other animals use the dry flower stems. One ant species is recorded nesting in the dead flower stems. Three native beetle species are also known to tunnel in the stems. Although the harvest of dead *Xanthorrhoea* roots and trunks (e.g. for wood turning) does not officially occur in Queensland, they are harvested in Western Australia. The larvae of at least three fly species, one moth species and the adults and/or larvae of four beetle species are known to live in the dead trunks of *Xanthorrhoea*. Ants have been recorded nesting in dead *Xanthorrhoea*. What impact the collecting of dead *Xanthorrhoea* trunks and roots has on these and other associated animals is unknown.

If as this review suggests there is a lack of evidence to show current *Xanthorrhoea* harvest is ecologically sustainable to both the plant and its associated animals, then alternatives to wild harvest may need to be examined. One alternative for consideration is the commercial cultivation of *Xanthorrhoea*. In nursery conditions some *Xanthorrhoea* can be grown from seed to flowering stage in about 5–6 years.

There are other factors that need consideration in determining ecological sustainability of *Xanthorrhoea* harvest. Knowledge about longevity, growth rates, time to maturity, flowering frequency, seed production, seed dispersal, seed predation and seedling establishment are all important in determining the sustainability of harvest. This knowledge is critical in determining recovery rates from harvesting. Although there is some knowledge of the biology and ecology of *X. johnsonii*, little is known for *X. latifolia*. Mean stem growth rate for *X. johnsonii* is estimated at 0.9cm per year, but is unknown for *X. latifolia*. However, based on the growth rate of *X. johnsonii*, and of other *Xanthorrhoea* species studied in Western Australia and the southern States, growth rate in *X. latifolia* can be expected to fall somewhere in the range 0.7–2.5cm per year. *Xanthorrhoea johnsonii* in south-east Queensland commence flowering when they are about 23 years of age when the trunk is about 20cm in height, and once mature will flower on average about once every five years to at least 300 years of age. There is no information for *X. latifolia* on the age that flowering commences, on flowering frequency and other aspects of its reproductive cycle, but this information can be partly inferred from our knowledge of *X. johnsonii*.

Flowering in *X. johnsonii* and a number of other *Xanthorrhoea* can be stimulated by fire and this is probably the case with *X. latifolia*. Seed maturation takes about three months in *X. johnsonii* in south-east Queensland, with up to 9174 seeds recorded per flower spike. Seed predation by the larvae of the moth *Meyriccia latro* can reduce seed set to zero. Isolated *X. johnsonii* (> 20m apart) sustain more seed predation and lower seed sets. This indicates thinning adult plants densities through activities like commercial harvest could impact on seed set and consequently seedling establishment. Although larvae of the moth *M. latro* can reduce seed set to zero, there has been no research on the long-term impact of *M. latro* seed predation on recruitment in *Xanthorrhoea* populations. The long-term impact of other seed predators such as rodents, birds and ants is also unknown. This may be of concern if habitat modification on farmland increases the number of *Xanthorrhoea* seed predators. There is very little knowledge of seed dispersal mechanisms, seed longevity and seedling establishment in the wild. Germination is affected by temperature, but other factors such as moisture, light and seed burial also affect germination.

Apart from possibly harvesting and clearing, it is unclear what other threats there are to *Xanthorrhoea* in Queensland. If there are significant threats apart from harvesting, then these may influence any decision on continuing wild harvest within Queensland. The impact of herbivores such as macropods on *Xanthorrhoea* inflorescences, seed production and seedling survival and growth needs to be investigated further. A better understanding is required of the impact of macropod grazing on Queensland *Xanthorrhoea*, especially the impact of the eastern grey kangaroo (*Macropus giganteus*) where their numbers are elevated because of human habitat modification. A Victorian *X. australis* study has already shown that up to nearly 80 percent of developing inflorescences can be either destroyed or seed production greatly reduced because of grazing. Of some priority is an assessment of the impact of grazing on *X. johnsonii* in mahogany glider habitat, where the inflorescences are considered an important food resource for this endangered glider.

Contrary to the popular belief that *Xanthorrhoea* are fireproof, there is evidence that fire can cause significant deaths in adult arborescent *Xanthorrhoea*. What constitutes an optimum fire regime for *Xanthorrhoea* is still unclear. Fire-free periods ranging from three to 13 years have been suggested as appropriate to maintain *Xanthorrhoea* populations elsewhere in Australia, although under four years may seriously impact on seedling survival and adult plants may still be fire-affected as much as 25 years post-fire. In south-west Western Australia there is evidence that pre-European fire frequencies were 3–5 years, although this doesn't mean these fire-free periods were optimum for *Xanthorrhoea*. Pre-European fire frequencies are still poorly known in the eastern States. Much research is still required to determine the optimum fire regimes for all Queensland *Xanthorrhoea* species in all habitats in which they occur.

The fungus *Phytophthora cinnamomi* is a significant threat to a number of *Xanthorrhoea* species from New South Wales across to Western Australia, but the little evidence available suggest the fungus is not a serious threat to Queensland *Xanthorrhoea*. However, the threat status of the fungus needs to be fully assessed in Queensland.

If harvesting of wild *Xanthorrhoea* is to continue in Queensland, and harvesting is to be ecologically sustainable, then actions recommended are:

1. Identify all invertebrates and vertebrates associated with *Xanthorrhoea* species that are wild harvested (whole plants or parts) in Queensland;
2. Identify important associations between wild harvested *Xanthorrhoea* (whole plants or parts) in Queensland and associated invertebrates and vertebrates;
3. Harvesters to determine the impact of *Xanthorrhoea* wild harvest, (whole plants or parts) on all vertebrates and invertebrates that have a significant association with Queensland *Xanthorrhoea*;
4. The Queensland EPA to ban harvesting of *Xanthorrhoea* foliage, inflorescences, seeds or whole plants where the endangered mahogany glider occurs;
5. No harvesting of dry inflorescences prior to seed fall, and if inflorescence harvesting is shown to significantly impact on insects boring into inflorescence stems (e.g. native bees), then harvesting to cease completely;
6. The identification of all *Xanthorrhoea* taxa that are wild harvested in Queensland and their distribution and population sizes determined;
7. Harvesters to show wild harvest of whole plants is not significantly depleting populations of any *Xanthorrhoea* taxa in Queensland, or altering their population structure to a point where reproductive output and recruitment are significantly reduced;
8. Based on information derived from recommendations 3 and 7, the Queensland EPA to either stop or at least annually adjust the level of non-salvage harvest of *Xanthorrhoea* whole plants, particularly if harvesting is shown to significantly affect associated vertebrates or invertebrates that are either endangered, vulnerable or rare;
9. The Queensland EPA to ensure only genuine *Xanthorrhoea* salvage harvest is allowed, with all reasonable options explored to remove the need for salvage to occur;
10. The Queensland EPA to ensure best-practice techniques are used to harvest whole plants from the wild;
11. Determine the survivorship of Queensland *Xanthorrhoea* plants taken from the wild for sale in the nursery trade, and where necessary encourage the development of better transplant and husbandry techniques to reduce death rates;
12. All significant harvesters of *Xanthorrhoea* foliage are to maintain foliage harvest monitoring sites as outlined in EPA guidelines and regularly provide accurate, unbiased measurement data from these sites to the EPA.
13. The Queensland EPA to review current *Xanthorrhoea* foliage harvest monitoring guidelines and where necessary up date methodologies so sampling methods, measurement variables and sample sizes are adequate for meaningful conclusions to be derived on the impact of harvesting on *Xanthorrhoea* populations and associated animals;
14. The Queensland EPA to review how *Xanthorrhoea* harvest monitoring programs are funded and staffed in Queensland, ensuring staffing skills, motivation and vested interests do not compromise monitoring data;
15. The Queensland EPA to ensure best-practice techniques are used to harvest *Xanthorrhoea* foliage;
16. The Queensland EPA to ensure an accurate measure of foliage harvested by standardizing weight measurement methodology;
17. The Queensland EPA to ensure *Xanthorrhoea* harvesters provide records that include the exact location of the harvest site, the estimated total area harvested, an estimate of the number of harvestable plants within this area, the number of plants harvested, an average percentage estimate of the foliage taken from each plant, the date when harvesting occurred, and where applicable, when a plant was previously harvested;
18. The Queensland EPA to develop and regularly update and maintain a centralized database for *Xanthorrhoea* foliage harvested in Queensland.
19. Harvesters to demonstrate *Xanthorrhoea* foliage harvest from the wild has no significant impact on *Xanthorrhoea* growth, reproduction and recruitment;
20. Based on information derived from recommendation 3, 17 and 19, the Queensland EPA to either stop or at least annually adjust the level of *Xanthorrhoea* foliage harvest, particularly if harvesting is shown to significantly affect associated vertebrates or invertebrates that are either endangered, vulnerable or rare;
21. The Queensland EPA to at least annually direct harvesters on the amount, locations and when foliage harvest can occur on State managed lands.

If it is decided harvesting of *Xanthorrhoea* whole plants and parts (e.g. foliage) is to cease or is to be drastically reduced, especially as this report found no compelling scientific evidence that current harvesting is ecologically sustainable, then it is recommended that:

1. Guidelines are developed in consultation with appropriate industry representatives to encourage the establishment of *Xanthorrhoea* plantations or nursery growing programs to meet public demand for whole plants and plant parts such as foliage;
2. Management guidelines are developed for the ecologically sustainable harvest of *Xanthorrhoea* seed from the wild for the establishment of plantation and nursery grown plants; and
3. A review is conducted of the current *Xanthorrhoea* tagging and compliance systems to ensure commercially grown whole plants and plant parts can be readily identified and illegal wild harvest discouraged.

There are still significant knowledge gaps for Queensland *Xanthorrhoea* regarding possible threats such as fire and the root rot fungus. If any of such possible threats are shown to be real threats to *Xanthorrhoea* in Queensland and are difficult to ameliorate, then they may influence the management of *Xanthorrhoea* harvest. Management recommendations in relation to these and other possible threats are:

1. Determine the optimum fire regimes for all Queensland *Xanthorrhoea* species in all habitats in which they occur;
2. Field assessment of the impact of the root rot fungus *P. cinnamomi* on *Xanthorrhoea* in Queensland;
3. Determine the impact of native and introduced herbivores on *Xanthorrhoea* in Queensland;
4. Determine the toxicity of all Queensland *Xanthorrhoea* to domestic stock and if required develop management options to minimize poisoning; and
5. Gather appropriate *Xanthorrhoea* life-stage data to allow robust modelling of population viability in relation to possible threats.

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