

Consultation on Species Listing Eligibility and Conservation Actions

Macrozamia johnsonii (Johnson's cycad)

You are invited to provide your views and supporting reasons related to:

1) the eligibility of *Macrozamia johnsonii* (Johnson's cycad) for inclusion on the EPBC Act threatened species list in the Endangered category; and

2) the necessary conservation actions for the above species.

The purpose of this consultation document is to elicit additional information to better understand the status of the species and help inform on conservation actions and further planning. As such, the below draft assessment should be considered to be **tentative** as it may change following responses to this consultation process.

Evidence provided by experts, stakeholders and the general public are welcome. Responses can be provided by any interested person.

Anyone may nominate a native species, ecological community or threatening process for listing under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or for a transfer of an item already on the list to a new listing category. The Threatened Species Scientific Committee (the Committee) undertakes the assessment of species to determine eligibility for inclusion in the list of threatened species and provides its recommendation to the Australian Government Minister for the Environment.

Responses are to be provided in writing by email to: species.consultation@awe.gov.au

Please include species scientific name in Subject field.

or by mail to:

The Director Bushfire Affected Species Assessments Section Department of Agriculture, Water and the Environment John Gorton Building, King Edward Terrace GPO Box 858 Canberra ACT 2601

Responses are required to be submitted by 5 January 2022.

Contents of this information package	Page
General background information about listing threatened species	2
Information about this consultation process	3
Consultation questions specific to the assessment	4
Information about the species and its eligibility for listing	12
Conservation actions for the species	24
References cited	27
Listing assessment	32

General background information about listing threatened species

The Australian Government helps protect species at risk of extinction by listing them as threatened under Part 13 of the EPBC Act. Once listed under the EPBC Act, the species becomes a Matter of National Environmental Significance (MNES) and must be protected from significant impacts through the assessment and approval provisions of the EPBC Act. More information about threatened species is available on the department's website at: https://www.awe.gov.au/environment/biodiversity/threatened/recovery-plans.

Public nominations to list threatened species under the EPBC Act are received annually by the department. In order to determine if a species is eligible for listing as threatened under the EPBC Act, the Threatened Species Scientific Committee (the Committee) undertakes a rigorous scientific assessment of its status to determine if the species is eligible for listing against a set of criteria. These criteria are available on the Department's website at: https://www.awe.gov.au/sites/default/files/env/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2021.pdf.

As part of the assessment process, the Committee consults with the public and stakeholders to obtain specific details about the species, as well as advice on what conservation actions might be appropriate. Information provided through the consultation process is considered by the Committee in its assessment. The Committee provides its advice on the assessment (together with comments received) to the Minister regarding the eligibility of the species for listing under a particular category and what conservation actions might be appropriate. The Minister decides to add, or not to add, the species to the list of threatened species under the EPBC Act. More detailed information about the listing process is at: https://www.awe.gov.au/environment/biodiversity/threatened/nominations.

To promote the recovery of listed threatened species and ecological communities, conservation advices and where required, recovery plans are made or adopted in accordance with Part 13 of the EPBC Act. Conservation advices provide guidance at the time of listing on known threats and priority recovery actions that can be undertaken at a local and regional level. Recovery plans describe key threats and identify specific recovery actions that can be undertaken to enable recovery activities to occur within a planned and logical national framework. Information about recovery plans is available on the department's website at: https://www.awe.gov.au/environment/biodiversity/threatened/recovery-plans.

Privacy notice

The Department will collect, use, store and disclose the personal information you provide in a manner consistent with the Department's obligations under the Privacy Act 1988 (Cth) and the Department's Privacy Policy.

Any personal information that you provide within, or in addition to, your comments in the threatened species assessment process may be used by the Department for the purposes of its functions relating to threatened species assessments, including contacting you if we have any questions about your comments in the future.

Further, the Commonwealth, State and Territory governments have agreed to share threatened species assessment documentation (including comments) to ensure that all States and Territories have access to the same documentation when making a decision on the status of a potentially threatened species. This is also known as the <u>'Common Assessment Method' (CAM)</u>. As a result, any personal information that you have provided in connection with your comments may be shared between Commonwealth, State or Territory government entities to assist with their assessment processes.

The Department's Privacy Policy contains details about how respondents may access and make corrections to personal information that the Department holds about the respondent, how respondents may make a complaint about a breach of an Australian Privacy Principle, and how the Department will deal with that complaint. A copy of the Department's Privacy Policy is available at: <u>https://www.awe.gov.au/about/commitment/privacy</u>.

Information about this consultation process

Responses to this consultation can be provided electronically or in hard copy to the contact addresses provided on Page 1. All responses received will be provided in full to the Committee and then to the Australian Government Minister for the Environment.

In providing comments, please provide references to published data where possible. Should the Committee use the information you provide in formulating its advice, the information will be attributed to you and referenced as a 'personal communication' unless you provide references or otherwise attribute this information (please specify if your organisation requires that this information is attributed to your organisation instead of yourself). The final advice by the Committee will be published on the department's website following the listing decision by the Minister.

Information provided through consultation may be subject to freedom of information legislation and court processes. It is also important to note that under the EPBC Act, the deliberations and recommendations of the Committee are confidential until the Minister has made a final decision on the nomination, unless otherwise determined by the Minister.

CONSULTATION QUESTIONS for Macrozamia johnsonii (Johnson's Cycad)

SECTION A - GENERAL

- 1. Is the information used to assess the nationally threatened status of the species robust? Have all the underlying assumptions been made explicit? Please provide justification for your response.
- 2. Can you provide additional data or information relevant to this assessment?
- 3. Have you been involved in previous state, territory or national assessments of this species? If so, in what capacity?

PART 1 – INFORMATION TO ASSIST LISTING ASSESSMENT

<u>SECTION B</u> DO YOU HAVE ADDITIONAL INFORMATION ON THE ECOLOGY OR BIOLOGY OF THE SPECIES? (If no, skip to section C)

Biological information

- 4. Can you provide any additional or alternative references, information or estimates on longevity, average life span and generation length?
- 5. Do you have any additional information on the ecology or biology of the species not in the current advice?

Ecological information

6. Can you provide any additional or alternate references, information or estimates on pollination ecology or pollinator biology

<u>SECTION C</u> ARE YOU AWARE OF THE STATUS OF THE TOTAL NATIONAL POPULATION OF THE SPECIES? (If no, skip to section D)

Population size (N.B. there is no total population size estimate for this species in the Conservation advice)

- 7. To your knowledge, is the wild population of Johnson's Cycad, a single panmictic (connected) population?
- 8. To your knowledge have there been estimates of adult population size?

9. Can you provide an estimate of the current population size of mature adults of the species (national extent)? Please provide supporting justification or other information.

If, because of uncertainty, you are unable to provide a single number, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of possible species numbers, and also choose the level of confidence you have in this estimate:

Number of mature individuals is estimated to be in the range of:

□ <10 000 □ 10 000 - 20 000 □ 20 000 - 30 000 □ 30 000 - 40 000 □ >40 000

Level of your confidence in this estimate:

- \Box 0–30% low level of certainty/ a bit of a guess/ not much information to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- \Box 51–95% reasonably certain, information suggests this range
- 95–100% high level of certainty, information indicates quantity within this range
- 99–100% very high level of certainty, data are accurate within this range

<u>SECTION D</u> ARE YOU AWARE OF TRENDS IN THE OVERALL POPULATION OF THE SPECIES? (If no, skip to section E)

- 10. Does the current and predicted rate of decline used in the assessment seem reasonable?
- 11. Do you consider that the way this estimate has been derived is appropriate? If not, please provide justification of your response.

Evidence of total population size change

12. Are you able to provide an estimate of the total population size in 2010 (at or soon after the start of the most recent 10 year period)? Please provide justification for your response.

If, because of uncertainty, you are unable to provide a single number, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of possible species numbers, and also choose the level of confidence you have in this estimate.

Number of mature individuals is estimated to be in the range of:

□ <10 000 □ 10 000 - 20 000 □ 20 000 - 30 000 □ 30 000 - 40 000 □ >40 000

Level of your confidence in this estimate:

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much information to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, information suggests this range

- 95–100% high level of certainty, information indicates quantity within this range
- 99–100% very high level of certainty, data are accurate within this range
- 13. Are you able to comment on the extent of decline in the species' total population size over the last approximately 10 years? Please provide justification for your response.

If, because of uncertainty, you are unable to provide an estimate of decline, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of decline, and also choose the level of confidence you have in this estimated range.

Decline estimated to be in the range of:

□ 1–30% □31–50% □51–80% □81–100% □90–100%

Level of your confidence in this estimated decline:

- \Box 0–30% low level of certainty/ a bit of a guess/ not much information to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- \Box 51–95% reasonably certain, suggests this range of decline
- 95–100% high level of certainty, information indicates a decline within this range
- 99–100% very high level of certainty, data are accurate within this range
- 14. Please provide (if known) any additional evidence which shows the population is stable, increasing or declining.

<u>SECTION E</u> ARE YOU AWARE OF INFORMATION ON THE TOTAL RANGE OF THE SPECIES? (If no, skip to section F)

Current Distribution/range/extent of occurrence, area of occupancy

- 15. Can you identify and list separate subpopulations for the species using IUCN definition of subpopulation –'geographically or genetically distinct groups with little demographic or genetic exchange of less than one migrant per year'
- 16. Can you provide presence/absence or abundance trend data for any of the subpopulations of this species?
- 17. Does the assessment consider the entire geographic extent and national extent of the species? Or is the current geographic extent smaller than that presented? Please provide justification for your response.
- 18. Has the survey effort for this species been adequate to determine its national distribution? If not, please provide justification for your response.
- 19. Is the distribution described in the assessment accurate? If not, please provide justification for your response and provide alternate information.
- 20. Are you aware of any subpopulations that are no longer extant.
- 21. Do you agree that the way the current extent of occurrence and/or area of occupancy have been estimated is appropriate? Please provide justification for your response.
- 22. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the extent of occurrence and/or area of occupancy.

If, because of uncertainty, you are unable to provide an estimate of extent of occurrence, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of extent of occurrence, and also choose the level of confidence you have in this estimated range.

Current extent of occurrence is estimated to be in the range of:

 \Box <100 km² \Box 100 – 5 000 km² \Box 5 001 – 20 000 km² \Box >20 000 km²

Level of your confidence in this estimated extent of occurrence

- \Box 0–30% low level of certainty/ a bit of a guess/ not much data to go on
- \Box 31–50% more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, data suggests this range of decline

 \Box 95–100% - high level of certainty, data indicates a decline within this range

99–100% - very high level of certainty, data is accurate within this range

If, because of uncertainty, you are unable to provide an estimate of area of occupancy, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of area of occupancy, and also choose the level of confidence you have in this estimated range.

Current area of occupancy is estimated to be in the range of:

 \Box <10 km² \Box 11 – 500 km² \Box 501 – 2000 km² \Box >2000 km²

Level of your confidence in this estimated extent of occurrence:

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much data to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, data suggests this range of decline

95–100% - high level of certainty, data indicates a decline within this range

99–100% - very high level of certainty, data is accurate within this range

<u>SECTION F</u> ARE YOU AWARE OF TRENDS IN THE TOTAL RANGE OF THE SPECIES? (If no, skip to section G)

Past Distribution/range/extent of occurrence, area of occupancy

- 23. Do you consider that the way the historic distribution has been estimated is appropriate? Please provide justification for your response.
- 24. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the former extent of occurrence and/or area of occupancy.

If, because of uncertainty, you are unable to provide an estimate of past extent of occurrence, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of past extent of occurrence, and also choose the level of confidence you have in this estimated range.

Past extent of occurrence is estimated to be in the range of:

 \Box <100 km² \Box 100 – 5 000 km² \Box 5 001 – 20 000 km² \Box >20 000 km²

Level of your confidence in this estimated extent of occurrence

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much data to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, data suggests this range of decline

- \Box 95–100% high level of certainty, data indicates a decline within this range
- \Box 99–100% very high level of certainty, data is accurate within this range

If, because of uncertainty, you are unable to provide an estimate of past area of occupancy, you may wish to provide an estimated range. If so, please choose one of the ranges suggested in the table below of ranges of past area of occupancy, and also choose the level of confidence you have in this estimated range:

Past area of occupancy is estimated to be in the range of:

 \Box <10 km² \Box 11 – 500 km² \Box 501 – 2000 km² \Box >2000 km²

Level of your confidence in this estimated extent of occurrence:

 \Box 0–30% - low level of certainty/ a bit of a guess/ not much data to go on

 \Box 31–50% - more than a guess, some level of supporting evidence

□ 51–95% - reasonably certain, data suggests this range of decline

 \Box 95–100% -high level of certainty, data indicates a decline within this range

99–100% - very high level of certainty, data is accurate within this range

PART 2 – INFORMATION FOR CONSERVATION ADVICE ON THREATS AND CONSERVATION ACTIONS

<u>SECTION G</u> DO YOU HAVE INFORMATION ON THREATS TO THE SURVIVAL OF THE SPECIES? (If no, skip to section H)

- 25. Do you consider that all major threats have been identified and described adequately?
- 26. To what degree are the identified threats likely to impact on the species in the future?
- 27. Are the threats impacting on different populations equally, or do the threats vary across different subpopulations?
- 28. Can you provide additional or alternative information on past, current or potential threats that may adversely affect the species at any stage of its life cycle?
- 29. Can you provide additional information on the historical loss of suitable habitat and the causes (e.g. land use change)?
- 30. Can you provide supporting data/justification or other information for your responses to these questions about threats

<u>SECTION H</u> DO YOU HAVE INFORMATION ON CURRENT OR FUTURE MANAGEMENT FOR THE RECOVERY OF THE SPECIES? (If no, skip to section I)

- 31. What planning, management and recovery actions are currently in place supporting protection and recovery of the species? To what extent have they been effective?
- 32. Can you recommend any additional or alternative specific threat abatement or conservation actions that would aid the protection and recovery of the species?
- 33. Would you recommend translocation (outside of the species' historic range) as a viable option as a conservation actions for this species?

<u>SECTION I</u> DO YOU HAVE INFORMATION ON STAKEHOLDERS IN THE RECOVERY OF THE SPECIES?

- 34. Are you aware of other knowledge (e.g. traditional ecological knowledge) or individuals/groups with knowledge that may help better understand population trends/fluctuations, or critical areas of habitat?
- 35. Are you aware of any cultural or social importance or use that the species has?
- 36. Are there any sub-populations of species that are co-managed by First Nations Peoples which are not currently recognised in the Cultural and Community Significance section of the Draft Conservation Advice.
- 37. What individuals or organisations are currently, or potentially could be, involved in management and recovery of the species?
- 38. How aware of this species are land managers where the species is found?
- 39. What level of awareness is there with individuals or organisations around the issues affecting the species?
 - a. Where there is awareness, what are these interests of these individuals/organisations?
 - b. Are there populations or areas of habitat that are particularly important to the community?

PART 3 – ANY OTHER INFORMATION

40. Do you have comments on any other matters relevant to the assessment of this species?

Conservation Advice for Macrozamia johnsonii (Johnson's cycad)

This draft document is being released for consultation on the species listing eligibility and conservation actions

The purpose of this consultation document is to elicit additional information to better understand the status of the species and help inform conservation actions, further planning and a potential recovery plan. The draft assessment below should therefore be considered **tentative** at this stage, as it may change as a result of responses to this consultation process.

<u>Note</u>: Specific consultation questions relating to the below draft assessment and preliminary determination have been included in the consultation cover paper for your consideration.

This document combines the approved conservation advice and listing assessment for the species. It provides a foundation for conservation action and further planning.



Macrozamia johnsonii, Dalmorton, NSW © Copyright, Dr Paul Meek (from Dept. Primary Industries, NSW Government)

Conservation status

Macrozamia johnsonii (Johnson's cycad) is proposed to be listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act* 1999.

Macrozamia johnsonii was assessed by the Threatened Species Scientific Committee to be eligible for listing as Endangered under criterion 2. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: B1ab(iii)+2ab(iii): Endangered
- Criterion 3: Ineligible
- Criterion 4: Ineligible
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing in the Endangered category are the restricted area of occupancy and extent of occurrence. The population is at risk of decline from both recruitment and pollination failure with an ongoing decline in habitat predicted under future climate change scenarios.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the <u>Species Profile and Threat Database</u>.

Species information

Taxonomy

Conventionally accepted as Macrozamia johnsonii D.L.Jones & K.D.Hill

Macrozamia johnsonii (Johnson's cycad) belongs to the family Zamiaceae and is closely related to *M. moorei*, a similar cycad in central Queensland, 800 km away (Binns & Meek 2008). Johnson's cycad has been included in the *M. moorei* taxon in the past (David Jones & Hill 1992).

Description

Johnson's cycad is a large cycad, with up to 120 stiff, bright green, glossy fronds in the crown, each between 1.5–3 m long on mature plants. Older plants may be as tall as two metres. The broad, cylindrical truck is up to 80 cm wide. The leaves are flat and arch from the centre trunk. The leaf stalk is 2–8 cm long and is spine-free (excluding the woolly, swollen base). The rhachis (leaf stem) has a gentle half spiral, flattened, shallowly convex above and usually 25–28 mm broad at the lowest pinnae. Between 150–250, moderately crowded pinnae emerge from the rhachis at about 40 degrees; the longest is between 20–40 cm long and 5–11 mm wide. Each pinna has a rigid, pointed tip, and those progressively closest to the rhachis are reduced inside to where they are eventually just the spines. Johnson's cycad is dioecious (having male and female plants). The reproductive structure (the cone) is stalked. Females have between 1–6 cones and males 10–50 per plant. Male cones are cylindrical, semi-erect to spreading, straight or

more usually curved, 25–40 cm long, and 8–10 cm in diameter. Sporophylls carry the pollen or the seed. Male sporophylls are wedge-shaped with an apical, erect, spine-like appendage 0.2–2 cm long. Female cones are cylindrical to barrel-shaped, green with pink areas on the sporophylls, 50–80 cm long, and 10–20 cm in diameter, usually spreading or drooping with age. Seeds are 4–6 cm long and between 2.5–3 cm thick and oblong. The sarcotesta (the fleshy outer layer of the seed) is bright red when ripe (Jones & Hill 1992a, b, NSW Government 2018a). For a more comprehensive description, see Jones & Hill (1992a) and an illustrated glossary of cycad specific terms can be found at (Haynes 2010).

Johnson's cycad is often confused with *M. moorei*, which grows up to 7m and has a similar trunk width of 50–80cm in diameter (NSW Government 2018).

Distribution

Johnson's cycad has a restricted distribution in the Dalmorton and Chaelundi area, west of Grafton, in north-eastern NSW (NSW Government 2018a). The geographic extent of the species was initially estimated as less than 100 km² (Jones & Hill 1992a, Hill 2003), though a subsequent assessment in 2008 found that the extent of occurrence was 222 km² (Binns & Meek 2008). Of the 222 km² extent, 140 km² (63 percent) occurred on forestry land (Chaelundi, Dalmorton and Marara State Forests), 22 km² (10 percent) occurred on private land, and 60 km² (27 percent) occurred in protected areas (Chaelundi National Park, Chaelundi State Conservation Area and Guy Fawkes River State Conservation Area) (Meek & Binns 2005,). Further field surveys in the National Park are needed to confirm this distribution. Within the distribution, Johnson's cycad may be sparse, though more often will form dense groves which number in their hundreds to thousands (Binns & Meek 2008).

Cycads are an ancient lineage of gymnosperms, recognised globally for their importance as extant representatives of plant evolutionary history. Many cycad species are threatened or extinct due to land use change, and relict habitats are expected to continue to contract under future climates (Stohlgren & Kumar 2013). The historical distribution of Johnson's cycad is unknown, so it possibly had a broader distribution in the past and may have been influenced by indigenous use of the species. In the southeast coastal province of the South West Australian Floristic Region (SWAFR), distribution of *Macrozamia dyeri* corresponded with precolonial Noongar occupation and movement patterns. *Macrozamia* seeds were transported to areas with water for detoxification, traded and shared (Lullfitz et al. 2017, 2019). The lack of contemporary human or mammal dispersal mechanisms may be the primary determinant of the restricted distribution of Johnson's cycad.



Map 1 Modelled distribution of Johnson's cycad

Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.

Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recently observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur), and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

This section describes some published examples of this significance but is not intended to be comprehensive, applicable to, or speak for, all Indigenous people. Such knowledge may be only held by Indigenous groups and individuals who are the custodians of this knowledge.

Cycads are a significant cultural species for many Indigenous people across Australia and Johnson's cycad occurs almost entirely in Gumbainggir Country although may have also been known to the adjacent Bundjalung and Ngarabal Peoples. Johnson's cycad is a food source, as are many other *Macrozamia* species across Qld, WA and NSW (Beaton 1982, Asmussen 2011). Due to the mast seeding in *Macrozamia*, their abundance supports sustenance for large community ceremonies and gatherings (Beaton 1982). Cycad seeds are toxic and only edible after extensive detoxification processes (a combination of some or all of: soaking, fermenting, roasting and grinding). These processes remove water-soluble azoglycosides, which are neurotoxic (Hegarty et al. 2001).

The species was named after the noted Australian plant taxonomist from the Royal Botanic Gardens, Lawrence A. S. Johnson (1925–1997), to recognise his pioneering studies in the family groups of Cycadaceae and Zamiaceae (Jones & Hill 1992a).

Johnson's cycad is a visually spectacular cycad and thus a popular garden plant cultivated by cycad and rare plant species enthusiasts.

Relevant biology and ecology

Population size and structure

Johnson's cycad grows in 'colonies' which have been recorded to be at a density of 228 mature plants in a 20-metre radius (Binns & Meek 2008). In 2008, the population size of Johnson's cycad was estimated using both mean densities from sampled plots multiplied by the total area and modelled abundance using mean counts from sampled plots and probability of occurrence based on moisture, slope and aspect. The methods employed by Binns and Meek (2008) estimated density at 158 plants per hectare and total abundance between 3.39 and 3.64 million mature plants. Densities are not constant throughout the distribution, and further survey is needed to refine spatial connectivity across the distribution. Seedling density and survival is high where there is a high density of adult plants. In 2008, a high proportion of the surveyed population was immature (80 percent), which indicated that it was a population of freely regenerating cohorts (Binns & Meek 2008).

Habitat and Community

Johnson's cycad grows on sheltered ridges and occurs in greater densities on steep southerly and easterly slopes in wet and dry sclerophyll forests and on the margins of rainforests. Johnson's cycad occurs on poor soils (skeletal clay loams with shale based soils) (Jones & Hill 1992a, b) where soil moisture is high, and there is a considerable slope (Binns & Meek 2008). It is unclear if the occurrence of Johnson's cycad on slopes is a habitat requirement or if those habitats were afforded more protection from clearing and other disturbances in the past.

Johnson's cycad occurs within an intergrading mosaic of grassy, open eucalypt forest and shrubby wet sclerophyll forest, with occasional patches of rainforest. Johnson's cycad often dominates the understorey where it occurs; though some co-occurring mid-story species are *Xanthorrhoea malacophylla* (grasstree), *Alectryon subcinereus* (native quince), *Cordyline petiolaris* (broad-leaved palm lily), *Croton verreauxii* (green native cascarilla), *Cryptocarya rigida* (forest maple), *Guioa semiglauca* (guioa), *Hibiscus heterophyllus* (native rosella), *Neolitsea australiensis* (green bolly gum), *Polyscias elegans* (celery wood) and *Trema tomentosa* (native/poison peach) (Doug Binns 2021. pers comm. 17 July).

Common canopy species occurring with Johnson's cycad include *Corymbia variegata* (a member of the spotted gum complex), *Eucalyptus microcorys* (tallowwood), *E. biturbinata* (grey gum), *E. carnea* (thick-leaved mahogany), *E. siderophloia* (grey ironbark) and *Lophostemon confertus* (brush box) (Binns & Meek 2008). The presence of cycad species in some forests has been documented as altering soil conditions. For instance, the presence of *Cycas micronesica* and *Samia integrifolia* in Florida karst (limestone) habitats in the United States is associated with

decreased phosphorus and increased nitrogen and carbon content in the soil beneath plants (Marler & Calonje 2020). Changes in soil chemistry associated with cycads were thought to improve the spatial heterogeneity of soil conditions with benefits to the ecosystem which include (increasing recalcitrant carbon and nitrogen and increasing spatial heterogeneity of soils chemistry) (Marler & Calonje 2020). The ability of Johnson's cycad to improve soil chemistry for the surrounding community is yet to be examined. Given that cycads can change soil chemistry, it's unclear if Johnson's cycad occurs in specific microhabitats, or facilitates the creation of those microhabitats; further research is needed.

Life history

Cycads are generally long-lived, with other *Macrozamia* species estimated to have a generation length of between 60–120 years (Benson & McDougall 1993). Johnson's cycad is dioecious, with both male and female individuals. The sex ratio in a population is difficult to determine without genetic analysis when the reproductive cones are not present. The onset of maturity can be difficult to determine but is often judged by the size of the leaf blades (Borsboom et al. 2015). Binns and Meek (2008) determined maturity by the presence of an above-ground caudex on the basis that plants without a caudex were rarely observed to produce cones. There are no published records of population demographic structure or sex ratio for Johnson's cycad.

Macrozamia species tend to mast seed in that they produce seeds synchronously within the population, though this may occur at unpredictable intervals interspersed with dormant years (Asmussen 2009, Borsboom et al. 2015). Four *Macrozamia* species from Qld and NSW produced between 50–360 seeds per female cone and had between one and eight cones per female (Asmussen 2009). The number of coning females tends to vary between years (possibly in response to fire and environmental variables, such as rainfall and soil condition) (Asmussen 2009).

Female plants of Johnson's cycad may have up to six cones, though three or four cones are more common. Male plants may produce between 10-50 cones (Jones & Hill 1992). A mature cone weighs up to 14 kg and contains more than 200 seeds (Thompson & Kennedy 2013). It is not known when Johnson's cycad seeds ripen, although in other *Macrozamia* species, seeds produced in March to April are ready to germinate 12 months later (Queensland Herbarium 2007). The process of seed dispersal in Johnson's cycad is also not known, though it may be facilitated by medium-sized mammals, though today, is likely facilitated by gravity and water runoff on the steep slopes where it occurs.

Cultivated specimens of Johnson's cycad produced cones after 15 years, and based on these observations, the estimated onset of maturity for wild individuals was between 20–40 years (Binns & Meek 2008).

Pollination

Most cycads have dependent mutualistic relationships with their specialised insect pollinators (Terry et al. 2005). The genus *Macrozamia* has around 40 species, and most are pollinated by invertebrate species of weevil, beetle or thrip (Toon et al. 2020). Johnson's cycad may be pollinated by two weevil species: *Tranes* sp. 2 (observed only in male cones); and *Enteles vigorsii* (observed only in female cones). The species *Exaireta spinigera* (the garden soldier fly) was also observed on a female cone, though may not have a pollination role as the larvae pupates in the

cones between the seeds and the species has not been recorded from cycad cones previous to this one observation (Forster et al. 1994).

The cones of cycads produce volatile components and emit thermogenic heat during certain parts of the day to repel and attract pollinators (Toon et al. 2020). Once inside the cone, the specialist pollinators display specific behaviours that result in the successful transfer of pollen to many ovules within the cone (Terry et al. 2005). Many weevils are obligate pollinators as they feed, mate, lay eggs and pupate in the cones of *Macrozamia* hosts (Forster et al. 1994, Terry et al. 2005). The garden soldier fly larvae pupate in the female cones between the seeds, though it is not known if they also visit the male cones, so they may not play a pollination role (Forster et al. 1994). The pollination ecology of Johnson's cycad has not been investigated, and much about pollinators are imapcted by geographic barriers (e.g. the Boyd River), which may influence genetic structure of the population.

Enteles vigorsii (a weevil species associated with Johnson's cycad) occurs from the northern Sunshine Coast (Qld) to south of Ballina (NSW) (Bachman et al. 2011). Publicly available sightings data suggest that *E. vigorsii* has an extent of occurrence of 24,000 km² and an area of occupancy of 152 km^{2;} which is broader than the current distribution of Johnson's cycad. Observations recorded by iNaturalistAU (2021) suggest there is a seasonality to observations, with a peak in the number of observations of the weevil between March and May. *Enteles vigorsii* has also been observed in the female cones of a cycad in Brisbane Forest Park (*Lepidozamia peroffskyana*; Forster et al. 1994) and so is likely not restricted to a single host cycad species.

Tranes sp. 2 was observed in the cones of several other cycad species in Qld and NSW (Forster et al. 1994, Terry et al. 2005, Toon et al. 2020).

Habitat critical to the survival

Modelled distributions of recorded Johnson's cycad suggest that environments with high moisture index (rainfall, evaporation, radiation and soil depth) on the southern and eastern slopes of the Dalmorton and Chaelundi ranges (Binns & Meek 2008) are critical for the species. The Grafton city council area experiences a total mean annual rainfall of 986 mm over 83 days of the year and the temperature ranges from 13–26°C (BOM 2021).

Habitat critical to the survival of Johnson's cycad includes the area occupied by all known populations (see the species distribution in Map 1), areas of similar habitat surrounding the population, additional occurrences of similar habitat that may be suitable for translocations or that contain undiscovered subpopulations of the species or be suitable for future translocations should ecological processes driven by climate change render the current area unsuitable.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

Given the restricted distribution, every wild population should be considered important.

Threats

Gymnosperms, and cycads in particular, are one of the most threatened groups of organisms (Mankga & Yessoufou 2017, Forest et al. 2018). Johnson's cycad adults are tolerant of fire, though frequent and high intensity fires threaten recruitment. It is not known if this species has undergone a historical retraction in distribution due to a history of land clearing, frequent fires or grazing. Johnson's cycad predominantly occurs on forestry land subject to cattle leases and may have been subject to inappropriate fire regimes. Johnson's cycad has a dedicated Species Management Plan for the portion of the population that occurs on NSW Forestry property.

Threat	Status ^a	Evidence
Habitat loss, degradat	ion, or fragmentation	
Destruction during timber harvest	Timing: current Confidence: observed Consequence: moderate Trend: unknown Extent: across part of its range	In 2008, destruction of plants due to timber harvesting activities was deemed a future threat. At the time, about 30% of the gross area of State Forest where the species occurs was available for harvesting (R. Kirwood, FNSW Resources Officer, pers. comm. 2007 in Binns & Meek 2008), the remainder being reserved for management exclusion zones or inaccessible due to topographic constraints (Meek & Binns 2005, Binns & Meek 2008). In 2009, Johnson's cycad experienced a post- logging loss of 2.3% of the total state forest subpopulation (Binns 2011). The current Coastal Integrated Forestry Operations Approval processes require Johnson's cycad to be protected by a 20 m buffer from logging activities, and subpopulations are now subject to a Species Management Plan and ongoing monitoring (NSW Government 2018b). These protective measures are conservation dependant and persist only as long as Johnson's cycad maintains a threatened listing status in NSW legislation. The combination of the 2019–2020 bushfires with the economic impacts from the COVID health epidemic will have lasting impacts on forestry management (ABARES 2021). The 2019-2020 bushfires impacted 130,000 hectares of plantation timbers. In NSW almost half (45%) of multiple-use public native forest was in the fire extent. Much of the harvestable timbers, and also canopy species in Johnson's cycad habitat, were impacted during the 2019-2020 bushfires. The topographic constraints which define the economic viability of harvestable areas in 2008, may no longer constrain harvest under current or future economic conditions. A current assessment of what portion of the
		distribution of Johnson's cycad is harvestable for other canopy species is required.
Clearing	Timing: current Confidence: observed Consequence: moderate Trend: static Extent: across part of its range	Cycads are recognised as poisonous to stock and so may be targeted for eradication on private land. A small proportion (10%) of the Johnson's cycad population is on a private grazing lease, which is subject to land clearing and annual maintenance fires. Binns and Meek (2008) state that the Johnson's cycad portion of the population which occurs on private land is unlikely to be cleared due

Table 1 Threats

to the topographic nature of the site (similar to

Threat	Status ^a	Evidence
		forestry lands, it occurs on steep slopes). Further research is required to determine if Johnson's cycad occurs on steep slopes due to suitable conditions or is occupying relic habitat which is unimpacted by clearing and grazing activities compared to more level areas. There is no current knowledge on the health of the populations on private lands and whether farm management practices maintain a self-recruiting population, or an aging one.
Fire		
Fire High fire frequency and intensity	Timing: current Confidence: projected Consequence: moderate Trend: increasing Extent: across the entire range	Frequency: Fire may be an essential ecological process for <i>Macrozamia</i> , as it alters soil chemistry and nutrient availability, improving conditions for reproduction (Beaton 1982). As cycads do not store seed in a seed bank for more than a few years, fire intervals of less than three years may impede recruitment. Binns & Meek (2008) found an increase in immature size classes where intentional fires for management had been reduced in frequency. A minimum five year fire interval was suggested for the related species <i>M.</i> <i>platyrachis</i> to allow seedlings to establish and be resilient to subsequent fires (Terry et al. 2008). Frequent fire will adversely impact the pollinator community, however, the fire interval required to preserve pollinators is unknown. Cycads form symbiotic relationships with nitrogen- fixing cyanobacteria and mycorrhizal fungi (Lindblad 2008). Fire affects soil structure and nutrient availability and a single fire may decrease the fungal species richness and in situ mycorrhizal colonization for a decade post fire (McMullan-Fisher et al. 2011, Dove & Hart 2017). It is not known whether fire impacts or improves the soil symbionts specific to Johnson's cycad. Annual fires implemented on grazing lands may be of lower intensity and so are unlikely to impact adult plants, though seedlings (<12 months old) may be killed (Doug Binns 2021. pers comm.1 July). Although the species has long persisted (50 years) in an area with a history of frequent burning for grazing (Binns & Meek 2008) the effect of this fire regime on the survival of new recruits is not known. Intensity: High-intensity fires can breach the fire-resistant trunk of mature plants and cause mortality (Binns & Meek 2008) and will also destroy seeds (Terry et al. 2008). Adult and juvenile plants (with more than ten leaves) (Meek & Binns 2005) are resilient to single fire events and have been observed to resprout after low and high-intensity fires (Binns and Meek 2008; Scott Filmer 2021. pers comm.26
		year post-fire (Doug Binns 2021. pers comm. 1 July). The 2019-2020 bushfires overlapped with almost 100% of Johnson's cycad modelled distribution (Gallagher 2020), and 72% burnt at very high and high fire intensities making this a priority species

Threat	Status ^a	Evidence
		for post bushfire assessment (Gallagher 2020). Post- fire surveys are yet to be conducted for the species, but a visual inspection of the population at Chaelundi National Park and Marara State Forest confirms that most adult Johnson's cycad were resprouting, and for a number of months Johnson's cycad were the dominant lower and mid-story vegetation post-fire (Scott Filmer 2021. pers comm. 26 July). The effects of recurrent high intensity fires have not been assessed. Climate change is predicted to increase both the frequency and intensity of bushfires (projected
		increase in the average number of fire weather and severe fire weather days) for most of NSW (NSW Government 2014).
Pollination ecology		
Pollination failure	Timing: future Confidence: suspected Consequence: major Trend: unknown Extent: across the entire range	Like other <i>Macrozamia</i> species, Johnson's cycad has obligate mutualistic relationships with only one or two specific insect species (<i>Enteles vigorsii</i> and <i>Tranes</i> sp. 2, both weevils) (Forster et al. 1994, Toon et al. 2020). Species that are dependent on specific pollinators have been shown to be more prone to extinction (Traveset et al.2017). Three major drivers of pollinator species loss and also disruption to pollination processes are habitat transformation, climate change and biological invasions (Traveset et al. 2017). <i>Pollinator decline or extinction:</i> Climate change is predicted to drive shifts in environmental conditions (temperature, precipitation, fire weather). Frequent fires may reduce the abundance of pollinator species (Terry et al. 2008). In Texas the red imported fire ant (<i>Solenopsis</i> <i>invicta</i>) predated on (and decreased) populations of the pest boll weevil (<i>Anthonomus grandis</i>) from cotton fields (Sterling et al. 1984). The red imported fire ant makes repeated incursions into Australia but has not spread far past the Qld border (Invasive Species Council 2017) and so may be considered a future threat to Johnson's cycad pollinators. <i>Pollinator / plant temporal mismatch</i> : Environmental changes may cause asynchrony between key biological phases of either the pollinating weevil species or Johnson's cycad, leading to declines in pollination. The late instar phase of the <i>Tranes</i> species of weevil (which pollinates Johnson's cycad) may burrow into the soil to pupate (Hall et al. 2004). The effect of intense or frequent fires on pupae prior to hatching is unknown. If Johnson's cycad relies on a mass hatching prior to pollination, then pollination failure may occur. Weevil development is temperature dependant; the development is temperature (Inward et al. 2012). Hatching and migration rates for other Weevil species are predicted to shift in response to
		rising air temperatures (Eickermann et al. 2014; Junk et al. 2012).

Threat	Status ^a	Evidence
		The unpredictable timing of mast coning events in <i>Macrozamia</i> species will likely contribute to variability in the availability of pollinator populations. Pollination failure is a recognised threat to five southern Qld cycad species (Laidlaw & Forster 2012). <i>Pollinator distribution shift:</i>
		Many eastern Australian weevil species are predicted to make poleward distributional shifts in response to rising temperatures due to climate change (Andrew & Hughes 2004; and see section below: Increased temperatures and changes in rainfall patterns). Weevil absence is difficult to detect in the environment, as they may be cryptic in cone debris or crevices in the trunk of a plant. Weevils spend part of their life cycle underground, and some pollinators may burrow into the subterranean trunks of cycads. For this reason, a lack of pollinator presence may not be an indication of pollinators were not detected in a subpopulation that was successfully reproducing (Paul Forster 2021. pers. comm. 23 July).
Climate Change		
Increased temperatures and changes in rainfall patterns	Timing: future Confidence: projected Consequence: moderate Trend: unknown Extent: across the entire range	Johnson's cycad is more abundant in habitats with a high moisture index (an index derived by comparing sightings with rainfall, evaporation, radiation, and soil depth) (Binns & Meek 2008). In the north coast region of NSW, there are projected increases in both minimum and maximum temperatures (maximum 0.4–1.0°C by 2039 and 1.5-2.4°C by 2060–2079) and an increase in the number of hot days (days above 35°C). Rainfall is projected to decrease in winter and increase in autumn and spring (NSW Government 2014). Climate change has been noted as a threat for five <i>Macrozamia</i> species from the Darling Downs area of Qld which are listed as threatened under Qld legislation (Laidlaw & Forster 2012). The specific habitat requirements of these cycads may result in individuals being restricted to refugia as climate changes (Laidlaw & Forster 2012) and this is also likley for Johnson's cycad The combination of slow growth, short dispersal distances and long generation times of several <i>Macrozamia</i> species make the genus vulnerable to the projected rate of climate change (NSW Government 2014).
Disease and infestatio	n	
Dieback from parasitic invertebrates or <i>Phytophthora</i> <i>cinnamomi</i>	Timing: future Confidence: suspected Consequence: moderate Trend: unknown Extent: across the entire range	A Diaspidid (armoured scale insect) was found to be the primary source of dieback in a population of <i>M.</i> <i>communis</i> in Murramarang National Park, southern NSW. Mortality was highest among seedlings and caulescent plants. Fire likely plays a protective role, as infestation of plants was lower in areas with a more frequent fire history (McDougall et al. 2021). There are no current records of this pest in northern NSW where Johnson's cycad occurs. <i>Phytophthora cinnamomi</i> is an introduced soil- borne pathogenic oomycete to which many Australian plants are susceptible. Infection with <i>P.</i> <i>cinnamomi</i> results in plant death through the

Threat	Status ^a	Evidence
		destruction of root systems and is listed as a Key Threatening Process under the EPBC Act (Department of Energy and Environment 2018). Some species of cycad are susceptible to <i>P.</i> <i>cinnamomi</i> , which may be spread by the movement of vehicles and logging equipment and through human mediated movement of soil. The susceptibility of Johnson's cycad to <i>P. cinnamomi</i> and the presence of the pathogen in the soils within the range of the species are unknown (NSW Government 2012). The remoteness of Johnson's cycad on NSW Forestry and National Park properties lends it some protection from <i>P.</i> <i>cinnamomi</i> , as most of the population is far from roads or paths (Doug Binns 2021. pers comm.1 July) where spread of the pathogen is most likely to occur. Infection by insects or <i>P. cinnamomi</i> will likely decrease the resilience of cycad Johnson's cycad to pressures such as natural predators (e.g. <i>Theclinesthes onycha</i> (cycad blue butterfly) or the beetle <i>Lilioceris nigripes</i> , which both have overlapping distributions with Johnson's cycad and are known to predate on other cycads (Queensland Herbarium 2007)). The cycad blue butterfly were observed to be abundant on young fronds of post- fire individuals <i>M. platyrhachis</i> (in Qld) (Terry et al. 2008), which may hinder post-fire recovery.
Poaching		
Illegal harvesting of plants or seeds	Timing: future Confidence: suspected Consequence: not significant Trend: unknown Extent: unknown	Johnson's cycad is a popular garden species, with seeds and plants sold both nationally and internationally (Bins & Meek 2010, Thompson & Kennedy 2013). The occurrence and extent of illegal collection are unknown, although due to the size of the adult and the access restraints and difficulty of the terrain, poaching is unlikely to occur for adult plants. Further, the nursery trade is a reliable source of Johnson's cycad individuals, and enthusiasts are likely to access healthy specimens via reputable traders.

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, and they are: the life stage they affect, the duration of the impact, and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk	Very high risk
Likely	Low risk	Moderate risk	High risk Destruction during timber harvest Clearing and inappropriate fires regimes on private land High bushfire frequency and intensity	Very high risk	Very high risk
Possible	Low risk	Moderate risk	High risk Increased temperatures and changes in rainfall patterns	Very high risk	Very high risk
Unlikely	Low risk	Low risk	Moderate risk	High risk	Very high risk
Unknown	Low risk Illegal harvesting of plants or seeds	Low risk	Moderate risk Dieback from parasitic invertebrates or Phytophthora cinnamomi	High risk Pollination failure	Very high risk

Table 2 Risk Matrix

Priority actions have then been developed to manage the threat, particularly where the risk was deemed to be 'very high' (red shading) or 'high' (yellow shading). For those threats with an unknown or low-risk outcome (green and blue shading), it may be more appropriate to identify further research or maintain a watching brief.

Conservation and recovery actions

Primary conservation objective

That the population demographics and pollination ecology of Johnson's cycad are well understood and monitored and are indicative of long-term viability (>150 years) and increased levels of protection are provided on all tenures within the distribution of the species.

Conservation and management priorities

Habitat loss, disturbance, and modifications

• Continue to manage Johnson's cycad on forestry and other tenures through a comprehensive Species Management Plan.

- Where feasible, purchase portions of private land where Johnson's cycad occur, or negotiate conservation agreements to ensure populations on private lands are protected from fire.
- Develop appropriate criteria and indicators to review the effectiveness of management actions currently employed on public and private tenures. Improve protection measures where they are inadequate to ensure the long-term (100+ years) integrity of the population.

Fire

- Develop and implement a fire management strategy such that fire regimes are compatible with population persistence of Johnson's cycad.
- In areas where a fire is an essential part of forest management, plan for fires that are of mild to moderate intensity and are undertaken at intervals of three years or more.

Disease

- Report any evidence of new infection or infestation by pests such as Diaspidid (armoured scale insect) or infections such as *P. cinnamomi* in the vicinity of Johnson's cycad to all relevant stakeholders.
- Implement appropriate hygiene protocols to prevent the spread of known infestations and infections.
- Develop emergency responses to diseases or infections that may have an immediate detrimental impact on either Johnson's cycad or obligate pollinating species.

Breeding, seed collection, propagation, and other ex situ recovery action

• Collect and maintain ex-situ seed or living collections to ensure genetic diversity is captured.

Climate change and severe weather

- Identify current and future habitats likely to remain or become suitable habitats due to climate change.
- Undertake translocations to identified suitable sites where there is evidence of impacts on the population from changes in climate conditions and weather extremes.
- Monitor translocated individuals to maturity and seed set and monitor recruitment to ensure translocated populations are viable and secure.

Stakeholder engagement/community engagement

- Engage and involve Traditional Owners in conservation actions, including survey, monitoring and management actions.
- Enhance communication between stakeholders (Garden centres and expert cultivators or enthusiasts of the species, Forestry NSW, Private landowners, National Parks and Conservation Area managers) to ensure that up-to-date biological and population data, appropriate fire regimes, and scientific knowledge is available to improve conservation measures for the species.
- If appropriate, engage interested community groups to participate in surveys and monitoring of the species within established guidelines for hygiene management and site access.

Survey and monitoring priorities

- Monitor types and levels of disturbance and recovery at sites where forestry activities intersect with Johnson's cycad distribution.
- Conduct surveys to determine population demographics (e.g., sex ratio, age, size) and reproductive status in response to environmental variables (e.g. aspect, fire, rainfall, temperature).
- Determine the response of different aged / sized Johnson's cycad to various fire intensities and frequencies.
- On forestry tenures, continue to support the *M. johnsonii* Species Management Plan, which identifies suitable habitat within operational areas, documents distribution and abundance, guides management actions and monitors the impact and recovery of forestry activities (NSW Government 2018).

Information and research priorities

- Determine ecological niche requirements to parameterise modelling of suitable habitat and identify current and future niches where population expansion and /or translocation might occur.
- Determine the role and importance of possible pollinator species (including *Tranes* sp. 2, *Enteles vigorsii*, and *Exaireta spinigera*).
- Determine the distribution, abundance, ecological requirements, and threats to the obligate pollinator species of Johnson's cycad.
- Determine the genetic structure and connectivity among geographically distant Johnson's cycad individuals. Identify if pollinator abundance affects population structure and if evolutionarily significant units (ESU) exist and, if so, collect seeds from at risk ESUs and adjust management plans accordingly.
- Determine the susceptibility of Johnson's cycad to *P. cinnamomi* and determine the risk to extant wild populations.
- Use predictive modelling to identify future threats and suitable habitats under various climate change scenarios.

Recovery plan decision

No recovery plan is in place for Johnson's cycad. This consultation document will elicit the additional information needed to inform the requirement of a Recovery Plan for Johnson's cycad.

Links to relevant implementation documents

<u>NSW Government (2010) Northern Rivers regional biodiversity management plan. A national</u> <u>recovery plan for the Northern Rivers Region. Department of Environment, Climate change and</u> <u>Water.</u>

NSW EPA (2018) Coastal Integrated Forestry Operations

Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (2018)

Northern Rivers Regional Biodiversity Management Plan (2010)

Conservation Advice and Listing Assessment references

- Andrew NR & Hughes L (2004) Species diversity and structure of phytophagous beetle assemblages along a latitudinal gradient: predicting the potential impacts of climate change. *Ecological Entomology* 29, 527–542.
- Asmussen B (2009) Another burning question: Hunter-gatherer exploitation of *Macrozamia spp. Archaeology in Oceania* 44, 142–149.
- Asmussen B (2011) Changing perspectives in Australian archaeology, Part X. There is likewise a nut. . . a comparative ethnobotany of Aboriginal processing methods and consumption of Australian *Bowenia, Cycas, Macrozamia* and *Lepidozamia* Species. *Technical reports of the Australian Museum* 23,10, 147-163.
- Bachman S, Moat J, Hill AW, de la Torre J & Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. Data from Global Biodiversity Information Facility (GBIF).
- Beaton A (1982) Fire and water: aspects of Australian Aboriginal management of cycads. *Archaeology in Oceania*, 17, 1, 51–58.
- Bell S (2015) Distribution, habitat and conservation status of *Macrozamia flexuosa* (Zamiaceae) in Lake Maquarie LGA and the lower Hunter Valley of New South Wales. Eastcoast Flora Survey Report, Kotara Fair, NSW.
- Benson D & McDougall L (1993) Ecology of Sydney plant species Part 1: ferns, fern allies, cycads, conifers and dicotyledon families Acanthaceae to Asclepiaceae. *Cunninghamia* 3, 257–422.
- Binns DL & Meek P (2008) Population size, habitat and conservation status of an Endangered species, *Macrozamia johnsonii* (Zamiaceae). *Cunninghamia* 10, 373–380.
- Bins BL & Meek P (2010) Macrozamia johnsonii. The IUCN Red List of Threatened Species 2010.
- Borsboom AC, Wang J & Forster PI (2015) Determining maturity and population structure in *Macrozamia parcifolia* (Zamiaceae), a threatened Australian cycad. *Australian Journal of Botany* 63, 392–402.
- Bureau of Meteorology (BOM) (2021) Climate statistics for Australian locations. Summary statistics Grafton City Council. Viewed 13 September 2021. Available at: http://www.bom.gov.au/climate/averages/tables/cw_058024.shtml
- Department of Agriculture Water and the Environment (2020) 2019-20 Bushfires recovery planning regional profile rainforests of the NSW north coast and tablelands. Australian Government, Canberra.
- Department of Energy and Environment (2018) *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi*. Australian Government, Canberra.

- Dove NC & Hart SC (2017) Fire reduces fungal species richness and in situ mycorrhizal colonization: A meta-analysis. *Fire Ecology* 13, 37–65.
- Eickermann M, Beyer M, Goergen K, Hoffmann L & Junk J (2014) Shifted migration of the rape stem weevil *Ceutorhynchus napi* (Coleoptera: Curculionidae) linked to climate change. *European Journal of Entomology* 111, 2, 243–250.
- Forest F, Moat J, Baloch E, Brummitt NA, Bachman SP, Ickert-Bond S, Hollingswoth PM, Liston A, Little DP, Mathews S, Rai H, Rydin C, Stevenson DW, Thomas P & Buerki S (2018) Gymnosperms on the EDGE. *Scientific Reports* 8, 1–11.
- Forster PI, Machin PJ, Mound L & Wilson GW (1994) Insects associated with reproductive structures of cycads in Queensland and Northeast New South Wales, Australia. *Biotropica* 26, 217.
- Gallagher R V (2020) Final national prioritisation of Australian plants affected by the 2019-2020 bushfire season. Report to the Commonwealth Department of Agriculture, Water and the Environment. Australian Government, Canberra.
- Gallagher R V., Allen S, Mackenzie BDE, Yates CJ, Gosper CR, Keith DA, Merow C, White MD, Wenk E, Maitner BS, He K, Adams VM & Auld T (2021) High fire frequency and the impact of the 2019–2020 megafires on Australian plant diversity. *Diversity and Distributions* 27, 1166–1179.
- Haynes JL (2010) *The Cycad Society. Illustrated glossary of cycad terms.* Viewed: 23 June 2021 Available at: <u>http://www.cycad.org/publications/illustrated_glossary.htm</u>
- Hegarty MP, Hegarty EE, Wills RBH (2001) *Food Safety of Australian Plant Bushfoods*. Kingston, ACT. Viewed: 23 June 2021 Available at: <u>http://www.rirdc.gov.au/reports/npp/01-28.pdf</u>
- Hall JA, Walter GH, Bergstrom DM & Machin P (2004) Pollination ecology of the Australian cycad *Lepidozamia peroffskyana* (Zamiacea). *Australian Journal of Botany* 52,333–343.
- Hill KD (2003) Regional overview: Australia, in: Donaldson J (ed) *Status survey and conservation action plan. Cycads*, 20–24. IUCN / SSC Cycad Specialist Group, Gland, Switzerland and Cambridge, UK.
- iNaturalist (2021) *Enteles vigorsii*. Viewed: 6 July 2021 Available at: https://inaturalist.ala.org.au/taxa/894803-enteles-vigorsii
- Inward DJG, Wainhouse D, & Peace A (2012) The effect of temperature on the development and life cycle regulation of the pine weevil *Hylobius abietis* and the potential impacts of climate change. *Agricultural and Forest Entomology* 14, 348–357.
- Invasive Species Council (2017) Fact Sheet: Red Fire Ants. Viewed: 20 August 2021, Available at: <u>https://www.invasives.org.au/wp-content/uploads/2015/01/Fact-Sheet-Red-Fire-Ants.pdf</u>

- IUCN *IUCN Redlist Generation Length Calculator*. Viewed: 13 January 2021 Available at: <u>https://www.iucnredlist.org/resources/generation-length-calculator</u>
- IUCN Standards and Petitions Committee (2019) *Guidelines for using the IUCN red list categories and criteria. Version 14.* Viewed 13 January 2021, Available at: <u>http://intranet.iucn.org/webfiles/doc/ssc/redlist/redlistguidelines.pdf</u>
- Jones D & Hill K (1992a) *Macrozamia johnsonii*, a new species of Macrozamia (Zamiaceae) from northern New South Wales. *Telopea* 5, 31–34.
- Jones D & Hill K (1992b) *New South Wales Flora Online. Macrozamia johnsonii*. Viewed:16 June 2021 Available at: <u>https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/nswfl.pl?page=nswfl&lvl=sp&name=macrozamia~johnsonii</u>
- Junk J, Eickermann M, Gorgen K, Beyer M & Hoffman L (2012) Ensemble-based analysis of regional climate change effects on the cabbage stem weevil (*Ceutorhynchus pallidactylus* (Mrsh.)) in winter oilseed rape (*Brassica napus* L.) Journal of Agricultural Science 150,2,191–202.
- Laidlaw MJ & Forster PI (2012) Climate predictions accelerate decline for threatened macrozamia cycads from Queensland, Australia. *Biology* 1, 880–894.
- Lindblad P (2008) Cyanobacteria in symbiosis with cycads, in: Pawlowski K (ed) *Prokaryotic Symbionts in Plants*, 225–233. Springer, Berlin.

Lullfitz A, Dortch J, Hopper SD, Pettersen C, Reynolds R & Guilfoyle D (2017) Human niche construction: Noongar evidence in pre-colonial southwestern Australia. *Conservation and Society*, 15, 2, 201–216.

Lullfitz, A (2019) *Vegetation responses to Noongar land management practices in old and young landscapes of south Western Australia*. PhD thesis. University of Western Australia.

- Mankga LT & Yessoufou K (2017) Factors driving the global decline of cycad diversity. *Annals of Botany Plants* 9, 4, 1-10.
- Marler TE & Calonje M (2020) Two cycad species affect the carbon, nitrogen, and phosphorus content of soils. *Horticulturae* 6, 1–10.
- McDougall KL, Gullan PJ, Craven P, Wright GT & Cook LG (2021) Cycad killer, qu'est-ce que c'est? Dieback of *Macrozamia communis* on the south coast of New South Wales. *Australian Journal of Botany* 69, 102–109.
- McMullan-Fisher SJMM, May TW, Robinson RM, Bell TL, Lebel T, Catcheside P & York A (2011) Fungi and fire in Australian ecosystems: A review of current knowledge, management implications and future directions. *Australian Journal of Botany* 59, 70.
- Meek PD & Binns D (2005) Species management plan Chaelundi and Dalmorton State Forests Macrozamia johnsonii (Zamiaceae). NSW Forestry, Coffs Harbour.

- NSW Government (2012) *Macrozamia johnsonii reject a proposal to delist an endangered species*. Viewed: 16 June 2021 Available at: <u>https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-</u> <u>species/nsw-threatened-species-scientific-committee/determinations/final-</u> <u>determinations/2011-2012/macrozamia-johnsonii-reject-delisting-of-endangered-</u> <u>species</u>
- NSW Government (2014) *New South Wales Climate change snapshot*. Viewed: 16 June 2021 Available at: <u>http://climatechange.environment.nsw.gov.au/climate-projections-for-nsw/climate-projections-for-your-region/nsw-climate-change-downloads</u>
- NSW Government (2018a) *Johnson's Cycad profile*. Viewed: 16 June 2021 Available at: <u>https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10503#:~:</u> <u>text=like</u>.
- NSW Government (2018b) *Coastal IFOA*. Viewed:5 July 2021 Available at: <u>https://www.epa.nsw.gov.au/your-environment/native-forestry/integrated-forestry-operations-approvals/coastal-ifoa</u>
- Queensland Herbarium (2007) National Multi-species Recovery Plan for the cycads, Cycas megacarpa, Cycas ophiolitica, Macrozamia cranei, Macrozamia lomandroides, Macrozamia pauli-guilielmi and Macrozamia platyrhachis. Queensland Government, Brisbane.
- Rossetto M & Kooyman RM (2005) The tension between dispersal and persistence regulates the current distribution of rare palaeo-endemic rain forest flora: A case study. *Journal of Ecology* 93, 906–917.
- Stohlgren TJ & Kumar S (2013) Endangered Plants. *Encyclopedia of Biodiversity: Second Edition* 3, 205–215.
- Sterling WL, Dean DA, Fillman DA & Jones D (1984) Naturally-occurring biological control of the boll weevil [Col.: Curculionidae]. *Entomophaga* 29, 1–9.
- Terry I, Forster PI, Moore CJ, Roemer RB & Machin PJ (2008) Demographics, pollination syndrome and conservation status of *Macrozamia platyrhachis* (Zamiaceae), a geographically restricted Queensland cycad. *Australian Journal of Botany* 56, 321–332.
- Terry LI, Walter GH, Donaldson JS, Snow E, Forster PI & Machin PJ (2005) Pollination of Australian *Macrozamia* cycads (Zamiaceae): Effectiveness and behavior of specialist vectors in a dependent mutualism. *American Journal of Botany* 92, 931–940.
- Thompson C & Kennedy P (2013) *Macrozamia johnsonii*. Viewed: 29 June 2021 Available at: https://www.pacsoa.org.au/wiki/macrozamia_johnsonii#seeds:
- Toon A, Terry LI, Tang W, Walter GH & Cook LG (2020) Insect pollination of cycads. *Austral Ecology* 45, 1033–1058.

Tozer MG & Keith DA (2012) Population dynamics of Xanthorrhoea resinosa Pers. over two

decades: implications for fire management. *Proceedings of the Linnean Society of NSW* 134, 249–266.

- Traveset A, Tur C & Eguíluz VM (2017) Plant survival and keystone pollinator species in stochastic coextinction models: Role of intrinsic dependence on animal-pollination. *Scientific Reports* 7, 1–10.
- Young LM, Marris JWM & Pawson SM (2008) Back from extinction: Rediscovery of the Canterbury knobbled weevil *Hadramphus tuberculatus* (Pascoe 1877) (Coleoptera: Curculionidae), with a review of its historical distribution. *New Zealand Journal of Zoology* 35, 323–330.

Other references

Doug Binns (2021) Independent botanical expert. Ex-NSW Forestry and Department of Environment, NSW Government. Personal Communication by phone and email. 1 July 2021.

Scott Filmer (2021) NSW National Parks Wildlife Service, Field officer. Department of Environment, NSW Government. Personal Communication by phone 26 July 2021.

Paul Forster (2021) Queensland Herbarium. Queensland Government. Personal Communication by email 23 July 2021.

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the Environment Protection and Biodiversity Conservation Act 1999

The Threatened Species Scientific Committee finalised this assessment on DD Month Year.

Attachment A: Listing Assessment for Macrozamia johnsonii

Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC.

Assessment of eligibility for listing

This assessment uses the criteria set out in the <u>EPBC Regulations</u>. The thresholds used correspond with those in the <u>IUCN Red List criteria</u> except where noted in criterion 4, subcriterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Key assessment parameters

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	>10,000	>10,000	3.64 million	An estimate of between 3.39 and 3.64 million mature plants was made in 2008 (Binns & Meek 2008) based on a mean density of 15,800 plants per km ² .
				The species is dioecious though the sex ratio is unknown; Binns and Meek (2008) proposed an effective population size of 900,000.
				In a national review of Australian cycads, Hill (2003) estimated stable population size of more than 10,000 mature plants, though no methodology was provided to support the estimate.
				The estimate used in this assessment was greater than 10,000; although no recent (or post 2019-20 bushfire) surveys have been conducted, the population size is not likely to have reduced to a point where it might be eligible for listing using the IUCN population size criteria.

Table 3 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Stable		·	Binns and Meek (2008) determined that there was no evidence for a historical decline in population size prior to 2008. Forestry declines have been minimal (Binns 2011). No data is available on population size in Conservation Areas, National Parks or private lands. In areas used for logging, a reported 33% of the total population was potentially harvestable from State Forests and 11% from private lands (NSW Government 2012).
Generation time (years)	49	33	65	Johnson's cycad is a long-lived species with low natural mortality and a long generation length. Longevity estimates for other <i>Macrozamia</i> species range between 60-120 years (Benson & McDougall 1993). The onset of maturity for Johnson's cycad is estimated at between 20-40 years and has between 1-6 female cones with about 200 seeds each (Binns & Meek 2008, 2010). <i>Macrozamia</i> reproduce at unpredictable intervals which include dormant years(Asmussen 2009). Generation length calculations were estimated using the IUCN generation length calculator, which estimates the mean age that a cohort reproduces (IUCN). Survival increased from 10% in the first 24 months to 90% between 7–100 years, then 50% between 100–120 years. Fecundity was set to 100 seeds at 20 or 40 years and increased to 700 seeds by age 34 or 44. Periods of four years with no reproductive output were estimated between reproductive years. The minimum estimate of generation length using maturity-onset of 20 years was 33 years. When the onset of maturity was set to 40 years, generation time was 50 years. The maximum estimate of generation time is 60 years based on published references (Bins & Meek 2010). The estimate used in the assessment was the median value between the minimum and maximum estimates

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Extent of occurrence	366 km ²	50 km ²	366 km ²	In a national review of Australian cycads, Hill (2003) estimated an extent of occurrence of 50 km ² using 2001 IUCN criteria. In 2008, Binns and Meek refuted this estimation and reviewed available records between 1952 and 2005, and estimated an EOO of 222 km ² (using minimum convex polygon) (Binns & Meek 2008).
				The maximum plausible EOO is based on mapping of point records from a 21-year period (1993-2014) obtained from DAWE and is 366 km ² using IUCN methodology (IUCN Standards and Petitions Committee 2019). The area of the 'known and likely' distribution (see Map 1, DAWE) of Johnson's cycad was estimated at 404 km ²
Trend	Stable			A national review of Australian cycads by Hill (2003) reported a habitat reduction of <10% in the 30 years preceding 2003. In 2008, Binns and Meek identified the main threat to be logging, and given the population was in an area of low risk, it was determined to be stable. Currently, populations of Johnson's cycad are managed on forestry lands under the Coastal IFOA (NSW Government 2018b).
Area of Occupancy	244 km ²	100 km ²	280 km ²	The minimum AOO was estimated to be 100 km ² on the basis of a review of all published locations in 2008 (Binns & Meek 2008, Bins & Meek 2010). The maximum plausible AOO was obtained from Bionet and State Forest entries data available through GBIF/ Geocat on 24 June 2021 sorted to eliminate "preserved specimens" and records outside of Dalmorton resulted in an AOO 280 km ² .
Travel	Challe.			is based on mapping of point records from a 21-year period (1993-2014) obtained from DAWE and is 244 km ² using IUCN methodology (IUCN Standards and Petitions Committee 2019)
Trenu	Stable			suggest AOO is in decline. The trend in AOO is assumed to be stable.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification	
Number of subpopulations	1	1	1	The population of Johnson's cycad is presumed to be one panmictic population, though this has not been confirmed. The species is most abundant in suitable microhabitats (on steep slopes with a higher moisture index) across the Dalmorton and Chaelundi areas. It is possible that spatial variation in pollination success could create genetic differentiation between microhabitats within the distribution. However, genetic evidence is needed to confirm this proposition Some records maintained in the BioNet database (single sightings from near Dundurrabin in 2008 and in New England National Park 2005) are from outside the known distribution of the main population. These were assessed to be likely errors in geocoding or location information (Doug Binns 2021. pers comm.1 July).	
Trend	Stable Currently, there is no evidence to suggest that more than one subpopulation exists, or that the known population is increasing or in decline. The number of subpopulations (1) is assumed stable.				
Basis of assessment of subpopulation number	The population in the areas of Dalmorton and Chaelundi are assumed to be one panmictic population. However, research is required to determine if cryptic divergence is present within the population.				
No. locations	1	1	1	The minimum number of locations used in the assessment is based on the risk of pollination failure.	
Trend	Stable			The trend is unknown, though presumed stable at present.	

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification	
Basis of assessment of location number	Frequent and intervals of less the some areas where inhibiting recruit monitoring regime not used to assess <i>Pollination failure</i> frequency increase may decrease as a asynchrony betw may eradicate loop.	ense fires causing re 9/20 bushfire imp d many adults are l 2021. pers comme han five years, wore e maintenance bur ment. There are no tes would not be so s location. e may occur if ther se as projected und a result (Terry et a een pollinator speci	ecruitment failure acted 98% of the p ikely to have survi s. 26 July). Several ald severely impact ns occur annually, o data on age struct afficient to detect r e is a loss in the ob der future climate of 1. 2008). Shifting cl plant cycles, or an es. The loss of poll	population, Johnson's cycad is highly ved (Doug Binns 2021. pers comm. 1 very intense fires, occurring in t recruitment. On private lands and in frequent fire may already be ture for the population and current ecruitment failure. Frequent fire was bligate weevil pollinators. Should fire change scenarios pollinator abundance limatic variables may cause i invertebrate decline or extinction inators is a likely cause of a southeast	
	recruiting (Paul Forster 2021, pers comm. 23 July).				
Fragmentation	The population of Johnson's cycad is not severely fragmented. No post-fire surveys have been conducted to determine if the population was fragmented due to the 2019/20 bushfires, though the adult population is presumed to be in a state of recovery.				
Fluctuations	The population of number of subpo species with low	f Johnson's cycad i pulations, location natural mortality a	s not subject to ext s or mature indivio and a long generati	reme fluctuations in EOO, AOO, duals. Johnson's cycad is a long-lived on time.	

Criterion 1 Population size reduction

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4						
		Critically Endangered Very severe reduction	Enda Seve	ngered re reduction		Vulnerable Substantial reduction
A1		≥ 90%	≥ 70%	6		≥ 50%
A2, A	.3, A4	≥ 80%	≥ 50%	6		≥ 30%
A1 A2	Population reduction observed, estimat past and the causes of the reduction are understood AND ceased. Population reduction observed, estimat past where the causes of the reduction be understood OR may not be reversibl	ed, inferred or suspected in clearly reversible AND ed, inferred or suspected in may not have ceased OR ma e.	a the	Based on	(a) (b) (c)	direct observation [except A3] an index of abundance appropriate to the taxon a decline in area of occupancy, extent of occurrence and/or quality of habitat
A3	Population reduction, projected or susp to a maximum of 100 years) [(<i>a</i>) cannot	bected to be met in the futur t be used for A3]	re (up	any of the following	(d) (e)	actual or potential levels of exploitation the effects of introduced
A4	An observed, estimated, inferred, proje- reduction where the time period must i future (up to a max. of 100 years in futu reduction may not have ceased OR may be reversible.	cted or suspected populatio nclude both the past and th ıre), and where the causes o not be understood OR may	on e of not			taxa, hybridisation, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

Insufficient data to determine eligibility

Declines from past bushfires

The 2019-2020 bushfires overlapped with 32 km² of Johnson's cycad modelled range; 31 km² were burnt which was 98 percent of the total range. Of that, 98 percent, 68 percent burnt at very high and high fire intensities, making this a priority species for post bushfire management (Gallagher 2020). Adult plants are more resilient to fire as they can resprout from the basal caudex, though seeds and seedlings are vulnerable to fire. There have not been any post-fire surveys to confirm declines in the adult population. However, an informal visual check of the Chaelundi National Park and Marara State Forest areas confirm that most observed individuals were in a state of resprouting and recovery. In areas of high fire intensity, Johnson's cycad formed the dominant lower and mid-story vegetation layer for the first six months post bushfires (Scott Filmer 2021. pers comm. 26 July).

Exposure to short fire intervals

Johnson's cycad is a slow-growing, long-lived species with an estimated generation time of 49 years (three generations is 147 years, but the maximum future time under this criterion is 100 years). There is concern that frequent fire (with intervals less than five years) may impact the survival of pollinators, seeds and seedlings. Observations at the Chaelundi National Park suggest that the population is bi-modal, with one age class dominating, interspersed with older individuals (Scott Filmer 2021. Pers comm. 26 July). Surveys are needed to investigate the forest

age structure to confirm that juveniles are not present and whether fire history is responsible. Long-term (23 years) monitoring of the long-lived, fire tolerant *Xanthorrhoea resinosa* identified trends that modelled a predicted extinction due to complex processes of mortality and competition (Tozer & Keith 2012). This study highlights that the long-term impacts of short fire intervals will also depend on post fire environmental conditions and competition. There are insufficient data to determine future declines in Johnson's cycad over the next 100 years at this time.

Conclusion

There are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy

		Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1.	Extent of occurrence (EOO)	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2.	Area of occupancy (AOO)	< 10 km ²	< 500 km ²	< 2,000 km ²
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(b)	(b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Criterion 2 evidence

Eligible under Criterion 2 B1ab(iii)+2ab(iii) for listing as Endangered

Geographic distribution and generation length

Johnson's cycad has an extent of occurrence (EOO) of 366 km² and an area of occupancy (AOO) of 244 km². A single generation is estimated to be 49 years.

Severely fragmented

Johnson's cycad is considered to occur as one population. The population exists in specific niches within the distribution (mostly south and eastern facing habitats, on a sloping territory with a high moisture index). Dispersal is limited and recruitment likely occurs close to the parent plant. Where adult plants are dense, shading may inhibit recruitment (Binns & Meek 2008). While there is only one population, genetic analyses can determine there is genetic differentiation within the distribution.

Number of Locations – Pollination failure due to temporal asynchrony or loss of pollinator

Johnson's cycad has an obligate relationship with Weevil pollinators (*Tranes* sp. 2 and/or *E. vigorsii*). The reliance on these species for pollination means that without them, Johnson's cycad may no longer reproduce. Wind pollination of cycads is not likely for Johnson's cycad, and is typically only successful for cycads in exposed and high wind areas (Toon et al. 2020). Johnson's cycad occurs in sheltered habitats (Binns and Meek 2008). In field exclusion experiments, the cycad (*Lepidozamia peroffskyana*) remained unpollinated when *Tranes* weevils were excluded, while still allowing pollen-bearing wind movements (Hall et al. 2004). *Enteles vigorsii* does not obligately rely on Johnson's cycad, as it has also been observed in the female cones of *L. peroffskyana*, in Brisbane Forest Park (Forster et al. 1994). Similarly, *Tranes sp. 2* was observed in the cones of several other cycad species in Qld and NSW (Forster et al. 1994, Terry et al. 2005, Toon et al. 2020).

Temporal asynchrony and shifting distributions

Changing climate (more high-temperature days and changing seasonality in precipitation in northern NSW) may interrupt pollinator ecology, causing asynchrony between cycad cone production and pollinator presence or behaviour (developmental rate, emergence and migration times) (Eickermann et al. 2014; Inward et al. 2012; Junk et al. 2012). Johnson's cycad is likely similar to other cycads in that it mast seeds (synchronous coning), though at unpredictable periods through spring and summer (Asmussen 2009, Borsboom et al. 2015). The temporal variability in mass coning is likely linked to environmental variables, which may shift with a changing climate.

The population biology, connectivity and home range of *Tranes* sp. 2 and *E. vigorsii* are not known. Sightings records for *E. vigorsii* report an extent of occurrence of 24,000km² between the northern Sunshine Coast (Qld) to the south of Ballina (NSW), which is about two degrees of latitude. The area of occupancy for *E. vigorsii* was 152 km² (Bachman et al. 2011) and observations recorded in iNaturalistAU (2021) suggest there is a seasonality to observations, with a peak in the number of observations of the weevil between March and May.

On the north coast region of NSW, there is a projected increase in the minimum and maximum temperatures (maximum 0.4–1.0°C by 2039 and 1.5-2.4°C by 2060–2079) and an increase in the number of hot days (days above 35°C). Such changes are predicted to cause a poleward distributional shift in many east Australian Weevil species (Andrew & Hughes 2004).

Should environmental changes cause the distribution of pollinators to shift away from the Dalmorton area, then reproductive failure of Johnson's cycad would likely occur. A temporal asynchrony between the emergence of pollinators and the maturation of cones would impact all adult Johnson's cycad in the tightly clumped distribution, and so a location of one is assigned.

Loss of pollinators

The Queensland species *M. platyrhachis* is listed as Endangered under state legislation and is pollinated by the thrip *Cycadothrips chadwicki* (Terry et al. 2008). Similar to Johnson's cycad, *M. platyrhachis* is a highly restricted species with extremely low dispersal capacity. Frequent fires have destroyed seeds and seedlings, and possibly also pollinators (as few were observed) (Terry et al. 2008). Similarly, *M. machinii* has at least one restricted subpopulation that is no longer recruiting, possibly due to the decline of *Tranes* sp. pollinators in the area (Paul Forster 2021. pers. comm. 23 July; Toon et al. 2020). Observed declines in the NSW species *M. flexuosa* were hypothesised to be caused by limitations in flowering, pollination or dispersal, with the longevity of adult specimens confounding the observable trends in long-term decline (Bell 2015). The reproductive status or pollination ecology of Johnson's cycad is not monitored so loss of pollinators or reproductive failure in the population may go unnoticed. Data on population structure, recruitment and pollination ecology are required to determine the long-term viability of the species.

Weevil extinction has been known to occur and is a feasible threat. The weevil species *Hadramphus tuberculatus* (the Canterbury knobbled weevil in New Zealand) was, for a time, presumed to be extinct (Young et al. 2008). Drastic population declines of the Canterbury knobbled weevil were attributed to habitat degradation and loss of host plants (as a result of grazing) and predation by rodents (Young et al. 2008). Due to the current abundance of Johnson's cycad, pollinators are not at immediate risk of decline from the loss of host plants, though they are likely at risk from frequent fires or poorly timed and intense fires (during sensitive life stages).

The loss of pollinators or temporal asynchrony would impact all adult plants in the tightly clumped distribution and so a location of one was assigned.

Continuing decline in area, extent and/or quality of habitat

A decline in habitat quality is projected for Johnson's cycad. The species predominantly occupies habitats on the eastern and southern protected slopes within its distribution and occurs in patches with a high moisture index (Binns & Meek 2008). Climate change predictions estimate that the north coast region of NSW will experience increased minimum and maximum temperatures, and the number of hot days will increase, rainfall will decrease in winter and increase in autumn and spring (NSW Government 2014). Forest Fire Danger Index is projected to increase in summer and spring, as is the number of days of severe fire weather. The low dispersal capacity of Johnson's cycad limits the ability of the species to rapidly shift distribution to keep pace with changing climate conditions. Increased ambient temperatures predicted up to 79 years into the future and under two different emission scenarios are expected to cause increased fragmentation and isolation of five threatened Qld Macrozamia species (M. cranei, M. viridis, M. conferta, M. machinii and M. occidua) in the Darling Downs region of Qld (Laidlaw & Forster 2012), which is less than 300 km NNW from Dalmorton, where Johnson's cycad population occurs. Precipitation and temperature changes, combined with increased fire frequency and intensity, are predicted to affect the area, extent and quality of suitable habitat for Johnson's cycad.

Conclusion

The Committee considers that the species' Extent Of Occurrence (EOO) and Area Of Occupancy (AOO) are restricted, and the number of locations is less than five. Predicted changes in climate

for northern NSW are projected to cause a continual decline in habitat quality, including habitat for obligate weevil pollinators. Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Endangered.

However, the purpose of this consultation document is to elicit additional information to better understand the subspecies' status. This conclusion is based on the acceptance that this species is severely fragmented and should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90 - 100%	95 - 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 Population size and decline

Criterion 3 evidence

Not eligible

Number of mature individuals

Following assessment of the data the Committee considers that the species is not eligible for listing in any category under this criterion as the total number of mature individuals is greater than 10,000.

Conclusion

The data presented above appear to demonstrate that the species is not eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. Number of mature individuals	< 50	< 250	< 1,000
D2. ¹ Only applies to the Vulnerable category Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time			D2. Typically: area of occupancy < 20 km² or number of locations ≤ 5

¹ The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the <u>common</u> <u>assessment method</u>.

Criterion 4 evidence

Not eligible

Number of mature individuals

As per the evidence presented above for Criterion 3, it is highly unlikely that the number of mature individuals is less than 1000. Additionally, the species is not eligible under criterion D2 under the EPBC Act.

Conclusion

The data presented above appear to demonstrate the species is not eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 5 Quantitative analysis

	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Criterion 5 evidence

Insufficient data to determine eligibility

Population viability analysis has not been undertaken.

Conclusion

There are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Adequacy of survey

The survey effort has been considered adequate, and there is sufficient scientific evidence to support the assessment.

Listing and Recovery Plan Recommendations

No recovery plan is in place for Johnson's cycad. A decision about whether there should be a recovery plan for this species has not yet been determined. The purpose of this consultation document is to elicit additional information to help inform this decision.

© Commonwealth of Australia 2021



Ownership of intellectual property rights

Unless otherwise noted, copyright (and any other intellectual property rights) in this publication is owned by the Commonwealth of Australia (referred to as the Commonwealth).

Creative Commons licence

All material in this publication is licensed under a <u>Creative Commons Attribution 4.0 International Licence</u> except content supplied by third parties, logos and the Commonwealth Coat of Arms.

Inquiries about the licence and any use of this document should be emailed to copyright@awe.gov.au.

Cataloguing data

This publication (and any material sourced from it) should be attributed as: Department of Agriculture, Water and the

 (\mathbf{i})

Environment 2021, Conservation Advice for Macrozamia johnsonii (Johnson's cycad), Canberra.

This publication is available at the SPRAT profile for Macrozamia johnsonii (Johnson's cycad).

Department of Agriculture, Water and the Environment GPO Box 858, Canberra ACT 2601 Telephone 1800 900 090 Web <u>awe.gov.au</u>

The Australian Government acting through the Department of Agriculture, Water and the Environment has exercised due care and skill in preparing and compiling the information and data in this publication. Notwithstanding, the Department of Agriculture, Water and the Environment, its employees and advisers disclaim all liability, including liability for negligence and for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying on any of the information or data in this publication to the maximum extent permitted by law.

Acknowledgements

The authors thank Matt Dobson, Doug Binns, Mick Andren and Paul Forster for their expert advice on Johnson's cycad, and Irene Terry for her insights into cycad pollination ecology.

Version history table

Document type	Title	Date [dd mm yyyy]
-	-	-
-	-	-