Hort Innovation

Final Report

Still wild about macadamias – conserving a national icon

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Delivery partner:

Healthy Land & Water Ltd

Project code:

MC15007

Project:

Still wild about macadamias – conserving a national icon MC15007

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Content

Summary

Wild macadamias are threatened with extinction over medium to long term timeframes due to issues arising from historical land clearing (e.g., isolated and small populations, loss of genetic diversity) and ongoing threats such as weeds and pests, inappropriate fire, pressure from human land uses and climate change.

This project, *Still Wild about Macadamias - conserving a national icon,* built on the achievements and foundation established through the Hort Innovation funded *Wild about Macadamias* project (MC10005) and implemented key actions identified in the Southern Macadamia Species Recovery Plan (2009).

The project was undertaken by Healthy Land and Water (HLW) in partnership with the Macadamia Conservation Trust (MCT) and Australian Macadamia Society (AMS) and with the support and involvement of industry representatives and macadamia researchers.

The overall objective of *Still Wild about Macadamias* was to improve understanding and management of the threats to wild macadamia trees and to promote and drive the protection and conservation of threatened wild populations, as well as to assist in the protection of other rainforest flora and fauna, including several threatened species and ecosystems. Target audiences for project communications included the macadamia industry, local, state and federal governments and private landholders.

Key activities included:

- Development of expert-endorsed habitat mapping and taxon profiles for *Macadamia integrifolia, M. tetraphylla* and *M. ternifolia* (Appendices 1-3);
- Surveys of priority macadamia populations and their habitats to assess status and threats;
- Repeat surveys of established monitoring plots for the commercially important *M. integrifolia* to collect data to assess response to long-term processes including habitat fragmentation and climate change;
- Production and dissemination of macadamia species identification factsheets;
- Production and dissemination of a land manager guide to macadamia conservation;
- Production and dissemination of a habitat fact sheet;
- Propagation workshop with Queensland Alliance for Agriculture and Food Innovation (QAFFI) attended by representatives from six local native nurseries;
- Collection and provision of 107 leaf samples from wild trees to Dr Catherine Nock, Southern Cross University (SCU) for genetic analysis;
- Development of 26 newsletter articles distributed through AMS via Facebook, e-news and Bulletin, posted on the MCT website and promoted by HLW;
- Development of articles for Arbor Age, Apr-May 2018, p62-65 (Appendix 4) and Calyx Horticultural Services' Get Results Gardening e-newsletter, Oct 2018 (Appendix 5);
- Rainforests of Subtropical Australia (ROSA) symposium (March 2017), which focused on improving understanding of macadamia habitats and conservation issues and attracted 342 practitioners, researchers and land managers from across south east Queensland and northern New South Wales;
- Information displays at events collectively attracting over 10,000 attendees, i.e., Logan Eco Action Festival (2014, 2015, 2016), Redlands Indigi Day Out (2016), Redlands Good Gardening Expo (2017), Sunshine Coast Conservation Forum (2015), World Science Festival (2018 Brisbane; 2019 Brisbane and Ipswich) and Australian Macadamia Industry Conference (2016);
- Presentation at the Australian Citizen Science Association Conference, 2018;
- Initiation of an industry sponsorship program for the Trust, now being successfully managed by the Trust;
- Progression of the revised species recovery plan, Macadamia Species Recovery Plan (2019-2024), through government approval and public consultation process;
- Development of Macadamia Conservation Action Plan for Redland and Logan City Councils;
- Assessment of the vulnerability of macadamia species and populations to climate change (internal report);

- Mapping of the invasive weed, Cats claw creeper, and assessment of risk to wild macadamia trees and their habitat in the Gympie region;
- Networking through internal and external networks to promote funding and partnership opportunities for onground macadamia conservation, e.g., support to private landholders in the Austinville Valley to restore and expand 15 hectares of *M. tetraphylla* habitat containing several large wild trees;
- Support to the MCT including hosting Committee meetings, assisting with governance improvements and strategic and business planning, contributing to funding proposals and applications and substantially raising MCT profile amongst the broader community and industry.

Major accomplishments included:

- Improved ability of local and state governments in Queensland to assess potential for development impact on macadamia habitat;
- Improved understanding and capacity of governments and land managers to address impact of threats to macadamia populations, including habitat fragmentation and climate change;
- Increased community and industry awareness of the status and significance of wild macadamias;
- Increased community capacity to identify and record data on macadamias;
- Improved understanding within the local native nursery industry of the importance of individual tree selection in propagating wild macadamias;
- Increased technical skills and knowledge within the local native nursery industry to propagate macadamias by cutting;
- Substantial contribution to improving understanding of the genetic diversity and relationships between wild populations and individual trees;
- Increased industry understanding and participation in macadamia conservation; and
- Significant improvements in the governance, capacity and profile of the MCT, now firmly on its way becoming a self-supporting and ongoing conservation program.

Still Wild about Macadamias significantly progressed understanding of wild macadamias and their conservation needs, however, it has also identified the need to continue building awareness and capacity within the macadamia industry and the wider community and for ongoing support for onground management of local threats.

Research advances during the project have highlighted the need for further surveys to assess population genetics and enable prioritisation for conservation and industry, particularly, populations vulnerable to climate change.

The completion of habitat mapping is a major step forward in providing planning and legislative protection of macadamia habitats in Queensland, however, this work needs to be undertaken for *M. jansenii* and more detailed vegetation mapping is required to achieve the same outcomes for New South Wales populations of *M. tetraphylla*.

Keywords

macadamia; threatened species; conservation; genetic research; monitoring surveys; education; recovery plan

Introduction

Macadamias are a national icon; with strong links to indigenous culture and childhood memories, they provide a connection with rainforest and are the basis of a valuable local and export industry. The survival of wild macadamias, however, is under threat and all four species are listed as threatened under State and Commonwealth legislation.

Australia also has obligations under the International Treaty on Plant Genetic Resources for Food and Agriculture (FAO 2009), to conserve the genetic resources of macadamia species for food and agricultural purposes.

The Macadamia Strategic Investment Plan 2017-2021 (Hort Innovation, 2017) identifies conservation of wild macadamia stocks as a deliverable that will assist with Outcome 2 (Improved production systems covering plant breeding, intensive orchards and novel technologies).

Still Wild about Macadamias built on the foundations established by Hort Innovation project MC10005, *Wild about Macadamias* (2010-2014), which was undertaken by the MCT and the Australian Macadamia Society (AMS).

Healthy Land and Water (HLW) provided technical and administrative support to the Trust and AMS for project MC10005 implementation and has been partnering in macadamia conservation since 2003. These activities and delivery of *Still Wild about Macadamias* contribute to the achievement of HLW's Strategic Goals:

- delivery of the South East Queensland Natural Resource Management Plan 2009-2031 (DERM 2009) and as updated in 2016 (SEQC 2016);
- innovative solutions to protect and restore our natural environment;
- attracting and retaining partnerships; and
- a connected, engaged and motivated community.

The main aim of *Still Wild about Macadamias* was to improve understanding and management of the threats to wild macadamia trees and to promote and drive the protection and conservation of threatened wild populations. Activities were coordinated with the support of the AMS, the Trust and the Trust's advisory body, the Macadamia Conservation Committee (MCC) and guided by the Draft Macadamia Species Recovery Plan 2019-2014 (Powell and Gould, 2019).

The project has assisted in the protection of other rainforest flora and fauna, including numerous threatened species and threatened ecosystems.

Key activities undertaken during *Still Wild about Macadamias* were:

1. assessment and monitoring of wild macadamia populations;
2. development of management strategies aimed at conserving threatened wild macadamia populations;
3. raising community-awareness of the status of wild macadamias through social media, educational material and events; and
4. establishing a self-supporting and ongoing conservation program supported by industry and the public.

Still Wild about Macadamias was aligned with project MC15008, *Establishing an open-source platform for unravelling the genetics of Macadamia: integration of linkage and genome maps,* undertaken by Dr Nock, which investigated the genetics behind key traits for conservation as well as crop development.

Methodology

Still Wild about Macadamias contained several key activities, each contributing towards the project's overall aims. The methodologies used for each are outlined in this section.

1. Assessment and monitoring of wild macadamia populations

Field surveys

Potential survey areas and locations were derived from data collected during *Wild about Macadamias*, anecdotal information from landowners/managers, Queensland government vegetation mapping and predictions from habitat models.

Determination of permit requirements and development of survey forms and leaf collection methods, including permission forms.

During surveys the location and demographic attributes (height, number of stems, basal area) for each macadamia tree in the survey area were recorded. In addition, an assessment of habitat condition and local threats to survival, e.g., weeds, fire vulnerability, livestock damage, was undertaken and any other significant flora or fauna noted.

Data generated through species surveys was provided to relevant land managers, including local governments, as well as provide to the Trust for inclusion in their database.

Long-term monitoring

Four long term monitoring plots were established as part of MC10005, *Wild about Macadamias,* at selected locations across the geographic range of *M. integrifolia*.

Repeat surveys of these sites as part of this project and conducted in 2017, repeated that methodology (Laidlaw et al 2011), comprising:

- locating each established 20m x 20m plot;
- identification of all species capable of reaching sub canopy level, together with their abundance, within in two categories:
    1. those plants <5cm diameter at breast height, i.e., recruitment class (count only); and
    2. those ≥5cm diameter at breast height (dbh), i.e., adult class (dbh measurement of each);
- measurement of the height and basal area of all macadamia species within the plot and a surrounding buffer 12.5m wide (total area 50m x 50m).

Data collected from each of the four sites was provided to the relevant land manager and collated into a report provided to the Trust.

The process of undertaking repeat surveys led to the identification of significant improvements needed to both the methodology documentation and the data collection process in order to improve data consistency and enable more rigorous analysis of data in the future.

Contribution to germplasm collections

At all sites where land manager permission was granted, leaf samples were collected and provided to Dr Nock (SCU) for genetic analysis. Each sample comprised 2-3 leaves (young leaves or fresh growth if possible), stored in a zip-lock bag with self-indicating silica beads and a specimen label with information on: collection date, site id, tree number, geographic coordinates, locality details, elevation, collector details and other information. A database recording leaf sample information was maintained, and copy provided to SCU. These leaf samples are now available for analysis as part of the MC18004 Project.

Assessment of vulnerability of macadamia species and populations to climate change impacts

In late 2017, the impacts of climate change on the distribution of macadamia habitats were investigated and reported on for milestone 105. Draft habitat mapping was assessed in relation to Climate Change Refuge and Adaptation Mapping undertaken by SEQ Catchments (2016) and compared to the climate niches identified for

Macadamia by Powell et al. (2014). The approach considered current (1990) climatic conditions and nine ecosystem and landscape factors.

The results were further analysed to address landuse change, comparing current landuse (Queensland Landuse Mapping Program, QLUMP 2009-2013) with future land use categories (DILGP 2017).

The outcomes will be used by HLW to progress and refine the SEQ Natural Resource Management Plan (DERM 2009, SEQC 2016) and other regional and sub-regional planning processes.

2. Development of management strategies

National recovery plan

In June 2014, the Draft Macadamia Species Recovery Plan 2014-2019 developed through MC10005, *Wild about Macadamias*, was submitted to Queensland and New South Wales state government agencies for review and endorsement.

In November 2015, following their review, the draft plan was submitted by the Queensland Department of Environment and Heritage Protection and the Department of Science, Information Technology and Innovation (Queensland Herbarium) to the Commonwealth Department of Environment (DoE).

In March 2017, the draft plan was assessed by the Commonwealth's Threatened Species Scientific Committee. The Committee agreed to recommend the plan for adoption by the Minister under the *EPBC Act 1999*, though also provided substantial comments requiring a detailed response.

In January 2018, HLW prepared a revised plan addressing the Committee's feedback and submitted it to the Commonwealth Department of Environment.

In June 2018, HLW assisted DoE to develop a targeted consultation list in preparation for public comment.

In March 2019, the plan was released for public comment with the revised title Draft Macadamia Species Recovery Plan 2019-2024. HLW advertised the opportunity for public comment throughout its network. Public comment closed on 07 June 2019 and submissions are currently being assessed by the DoE.

Habitat mapping

Habitat mapping in Queensland for each of the four species of macadamia was drafted through a spatial intersect of species records with Queensland Government remnant vegetation mapping (regional ecosystem Version 10.1) using ESRI ArcGIS software.

Consultation with an expert panel refined the draft mapping and categorised this into known or potential and into core, preferred or general habitats for each species. At this stage, due to a concurrent MCT project, work on *M. jansenii* was paused pending survey outcomes.

Taxon profiles were developed to describe each species, their habitat requirements and associated habitat mapping rules and reviewed by the expert panel for technical accuracy.

Endorsement of the final taxon profile and mapping was sought from expert panel members and the resulting final documents and data provided to the Biodiversity Assessment Unit of the Department of Environment and Science (DES) for:

- review and incorporation into regional planning assessments, e.g., Southeast Queensland Bioregion

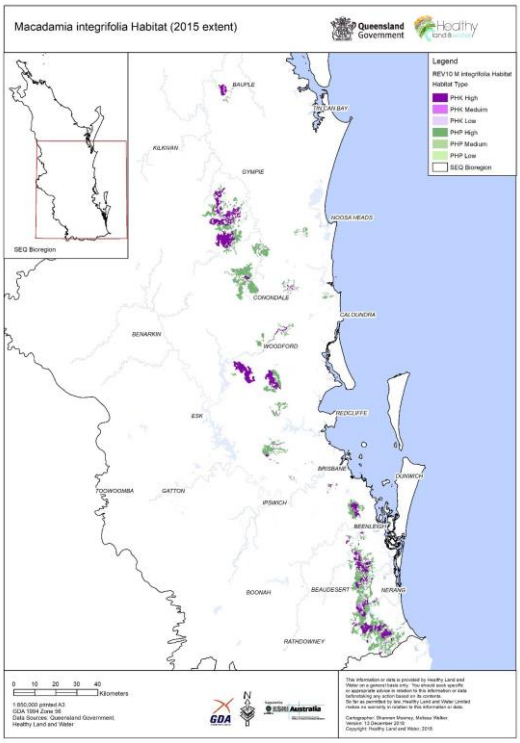


Figure 1. Habitat mapping for macadamia integrifolia *and other macadamia species will assist legislative and planning protection in Queensland; the map illustrates preferred known habitats (PHK) in shades of pink and possible (PHP) habitats in shades of green.*

Biodiversity Planning Assessment[1]; and

- forwarding to the Department of Natural Resources and Mines for inclusion of core habitats within the essential habitat layer administered under the Queensland *Vegetation Management Act 1999*.

One of the purposes of the *Vegetation Management Act 1999* is to regulate vegetation clearing to prevent the loss of biodiversity. To meet this obligation, maps of essential habitat are considered when assessing vegetation clearing applications to assist in determining whether the vegetation is habitat for species classed as Endangered or Vulnerable under the *Nature Conservation Act* (1992).

Thus, this component of *Still Wild about Macadamias*, will assist with legislative and planning protection of macadamia habitats in Queensland. Further, habitat categories not considered core or essential habitat, provide direction for future surveys and research.

Conservation Action Plans

Conservation Action Plans were developed for two local councils with significant populations of wild macadamia; the finalisation of habitat mapping (above) provides scope for these to be revised and for the Conservation Action Plan framework to be extended to other local government areas

Species records, draft habitat mapping, the outcomes of local surveys and information in the Draft Macadamia Species Recovery Plan 2019-2024 (Powell and Gould 2019), were analysed to develop local Conservation Action Plans for Redland and Logan City Councils. Each analysis included extent and distribution of remnant, regrowth and cleared habitats, habitat fragmentation, population size and distance between trees, weed, fire and landuse threats, climate change, genetic pollution and the impacts of public perception and uncoordinated conservation.

Targeted weed mapping

The exotic invasive weed, Cat's claw creeper (*Dolichandra unguis-cati*), is a major threat to wild macadamia populations and habitats, and particularly to priority populations of macadamia in the Amamoor district, near Gympie.

A project between Gympie and District Landcare and the Australian Macadamia Society, funded by the Queensland Government, undertook to build capacity to breed and release biocontrols for Cat's claw creeper; *Still Wild about Macadamias* was able to provide support through mapping to shows the proximity of Cat's claw creeper records to wild *M. integrifolia* trees and known and potential habitats.

This mapping was provided to Gympie and District Landcare and the Trust to guide further activities and target future monitoring of Cat's claw creeper.

Figure 2. The highly invasive Cat's claw creeper is a major threat to wild macadamia trees.

On-ground conservation

Networking and promotion through internal and external networks, e.g. Land for Wildlife, ensured macadamia remain on the priority list for conservation support.

Examples of the diversity of projects supported include:

- Conservation of 15 hectares of *M. tetraphylla* habitat through a separately funded partnership between Healthy Land and Water and the Gold Coast Catchment Association along Upper Mudgeeraba Creek, Austinville Valley. The project restored endangered lowland subtropical rainforest across a mix of tenures (Nature Refuge, road reserve, National Park and Council reserve), through weed control and infill planting, to the benefit of several *M. tetraphylla* trees within and near the project area.
- Discovery of a large population of *M. integrifolia* in Redlands, which led to support from that local Council

[1] https://www.qld.gov.au/environment/plants-animals/biodiversity/planning

to the landholder for weed control.

- Surveys and assessment of remnant trees at Brookside Shopping Centre, resulting in the propagation and growing-on of cuttings from mature trees designated for removal and their planting by local group, Save our Waterways Now, into appropriate nearby bushland.
- Inspiration for The Wild Macadamia Hunt (WMH) project, which extends ideas, partnerships and research developed during *Still Wild about Macadamias*. The WMH was initially focused on Brisbane and funded by Brisbane City Council, however, is about to expand to Queensland courtesy of an Office of Chief Scientist grant. WMH engages the community to find old macadamia trees, either *in situ* trees isolated through habitat clearing or trees translocated to backyards in the early 1900s, which could contain unique genomes. This project will build community awareness and provide data to inform conservation and horticulture.

3. Raising community awareness

Still Wild about Macadamias communications strategy involved coordination of a series of strategic activities and information products, and participation in events coordinated by other organisations.

Conferences and workshops

- Presentation at the Australian Citizen Science Association Conference, 2018: presenting the latest genetic research and the potential significant of backyard macadamia trees as reservoirs of genetic diversity potentially lost from the wild.
- Macadamia propagation workshop at Maroochy Research Station, August 2017: staff from native plant nurseries across south east Queensland and northern New South Wales were invited. The workshop comprised an introduction to macadamias and the latest genetic research findings, followed by hands-on skills training by QAFFI horticulturists in cutting collection and establishment. The purpose of the workshop was to give staff from native plant nurseries the skills to grow macadamias from cuttings and thus facilitate the planting of wild genetic material rather than commercial hybrids in revegetation plantings.

Figure 3. The propagation workshop provided hands-on training in collecting and growing macadamias from cuttings to facilitate conservation of the genetic integrity of wild trees.

- Rainforests of Subtropical Australia (ROSA) symposium, 23-24 March 2017: coordinated by HLW to raise awareness and share information between Queensland and New South Wales practitioners, managers and researchers of subtropical rainforests. These rainforests are the primary habitat for macadamias, so many of the learnings from ROSA contributed to macadamia conservation. The symposium attracted 342 attendees to sessions on climate change, management innovations, novel values and threatened species conservation and fire, a major threat to conservation of wild populations of macadamia, was discussed in detail through a dedicated panel session. Dr Nock (SCU) presented on macadamias, some of the findings from this project and her genetic research supported through MC15008.
- Australian Macadamia Industry Conference, 19-20 October 2016: trade stall, silent auction and pop-up display to engage with macadamia growers, processors and marketing representatives.

Figure 4. The Rainforests of Subtropical Australia symposium featured a presentation by Dr Catherine Nock, Southern Cross University (second from right), on "Conserving the Wild Relatives of macadamia".

Events and information sessions

Displays and presentations at events around the region provided information on the status of wild macadamias, their importance to industry, threats to survival and conservation actions required.

2014	Logan Eco Action Festival
2015	Logan Eco Action Festival Sunshine Coast Conservation Forum
2016	Logan Eco Action Festival Redlands Indigi Day Out Australian Macadamia Industry Conference, 19-20 October 2016: trade stall
2017	Logan Eco Action Festival Redlands Good Gardening Expo
2018	World Science Festival (Brisbane)
2019	World Science Festival (Brisbane and Ipswich)

Figure 5. Cracking macadamia nuts was popular at displays, providing perfect opportunity to discuss the status of wild macadamias.

Macadamia giftings

A census undertaken of the macadamia giftings of 2011-2013 found that most trees were thriving.

Each of four botanic gardens gifted with a set of the four macadamia species in 2011-2013, was contacted and requested to provide information on the following, with supporting photographs:

- Form, e.g. single or multi stemmed,
- Height
- Girth (dbh)
- Condition, e.g., healthy, poor, dead, etc. (and if not 'healthy' some further information)
- History of fruiting/flowering, etc

All trees were reported to be multi-stemmed, leading to small girth measurements, and most were healthy (the exception being *M. ternifolia* at Lismore Botanical Gardens). Trees growing in Brisbane were generally taller and M. integrifolia achieved a greater average height than the other species (Figure 1). Flower and fruit production were found to be highly variable between sites and between species.

Full results were captured in Milestone Report 106 and presented to the Trust.

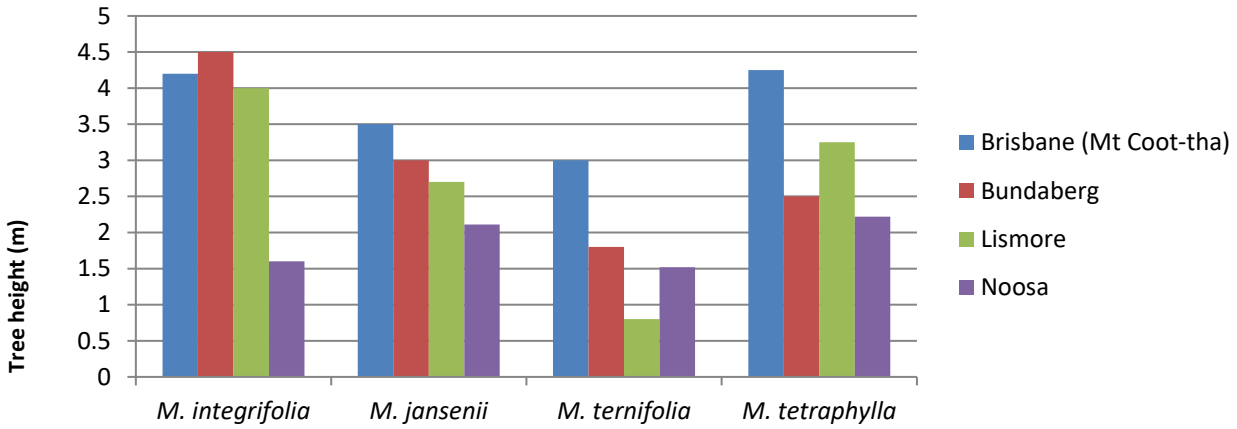


Figure 6. macadamia giftings tree height by species and site

Newsletter articles

Articles were regularly developed for publication in the AMS News Bulletin and AMS e-newsletter between Feb 2015 and Nov 2017) and, when relevant, in HLW e-news across the life of the project.

Social Media

The primary social media utilised during the project was Facebook, with both HLW and AMS posting updates from April 2015 to the end of project. The significant following of AMS's Facebook page enabled greater reach for conservation news amongst an engaged, but not necessarily conservation-minded audience distributed across Australia and overseas, whilst HLW's Facebook followers are typically more involved and aware of conservation issues, but not necessarily the macadamia story, and generally based in South East Queensland and surrounding regions. The AMS currently has 55,140 Facebook followers and HLW 9,676 followers; it is hoped many of these followers will also sign-up to the Trust's recently launched Facebook page (which currently has 108 followers).

The cumulative impact of the project in building awareness of macadamias was demonstrated through a HLW post promoting the Wild Macadamia Hunt, which reached 11,618 people, with 1,703 engagements and 76 shares.

More recently the Wild Macadamia Hunters Facebook group, associated with the Wild Macadamia Hunt project, and the Trust's Facebook page have been used to promote project activities and conservation issues. The group currently has 116 members.

Website

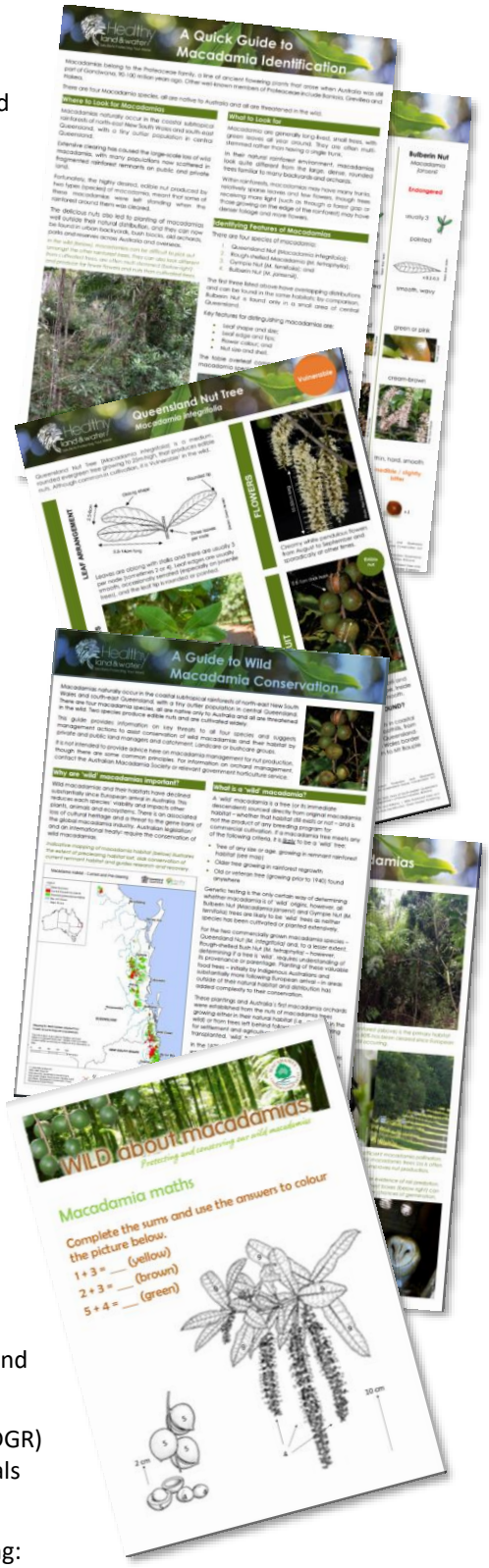
Still Wild about Macadamias' activities provided considerable content for the Trust's website (www.wildmacadamias.org.au), which was newly established at project initiation by the completing *Wild about Macadamias* project (MC10005). Regular updates and uploading of new resources, e.g., factsheets and education materials, promoted through e-newsletter articles and Facebook posts, greatly assisted to build the profile of Australia's wild macadamias and to support the Trust to become a self-supporting and ongoing conservation program.

Factsheets and education materials

These were a major output of the project and an investment in public education about macadamia conservation that will be used well beyond the life of *Still Wild about Macadamias*.

Several information products were developed during the life of the project (full listing provided in Outputs), including:

- macadamia identification fact sheets – summary fact sheet and individual fact sheet for each of the four species
- Land manager fact sheet, "Guide to Wild Macadamia Conservation"
- Factsheet on "Gallery rainforest on alluvial plains" regional ecosystem (12.3.1), featuring macadamia trees, published on HLW website and promoted via Facebook
- Flyers developed and sent to land managers with potential macadamia habitat in Redland and Logan City Council areas.
- Colouring-in and maths handouts for children



4. Establishment of a self-supporting and ongoing conservation program

In the wild, macadamias are slow-growing, long-lived and resilient; conservation of wild trees and their habitats is a long-term undertaking. A major focus of *Still Wild about Macadamias* was to establish conservation mechanisms with a lifespan longer than the project's timeframes; this was achieved through the development and dissemination of habitat mapping, conservation action plans and information products, and also through building the profile, capability and sustainability of the MCT in order for it to become a self-supporting and ongoing conservation program.

Stepping-stones to achieving this were determining and enabling the Trust's governance arrangements and improving its fund-raising capacity, including:

- Hosting of Macadamia Conservation Committee and Trust committee meetings;
- Providing input into the Trust's governance framework and business plan;
- Assisting to gain fund-raising permits for the Trust from Queensland and New South Wales governments; and
- Supporting the Trust's application for Deductible Gift Recipient (DGR) status to enable eligibility for grant funding, crowd-funding appeals and general donations.

Fundraising initiatives were also initiated on the Trust's behalf, including:

- Macadamia industry sponsorship and AMS members' annual appeal program – raising awareness within the industry of the status of wild macadamia stocks, their importance to industry and the need for financial support for conservation.
  - Industry sponsorship was pursued through a prospectus, sent to Australian macadamia processors and offering gold, silver or bronze levels of promotion through social media, newsletter articles and at events in return for financial support to the Trust.
  - The annual appeal was conducted as part of AMS membership annual renewals, with a leaflet and contribution form sent to members requesting contributions from growers to support the Trust's activities.
- Grant applications submitted to local governments and philanthropic funds. Awareness of available grant programs was boosted through annual subscription by HLW to the "Our Community" grant subscription service.

Figure 7. A silent auction of macadamia trees and other items at the AMS Conference built profile for the MCT and industry support for conservation.

Outputs

- Expert-endorsed habitat mapping and taxon profiles completed for *Macadamia integrifolia, M. tetraphylla and M. ternifolia,* refer Appendices 1-3 (May 2019) and drafted for M. jansenii (completion pending outcomes of current surveys by the Trust)
- Land manager guide to macadamia conservation (May 2019), http://www.wildmacadamias.org.au/PDFs/macadamia%20Conservation%20Land%20Managers%20Guide%20final%2024May2019.pdf
- Macadamia Species Recovery Plan 2019-2024 (July 2018), http://www.environment.gov.au/biodiversity/threatened/recovery-plans/comment/draft-recovery-plan-macadamia-species-2019-24
- Macadamia species identification factsheets (Aug 2018):
    - A Quick Guide to Macadamia Identification, https://hlw.org.au/download/a-quick-guide-to-macadamia-identification;
    - HLW *Macadamia integrifolia* identification fact sheet, https://hlw.org.au/download/hlw-macadamia-integrifolia-identification-fact-sheet)
    - HLW *Macadamia tetraphylla* identification fact sheet, https://hlw.org.au/download/hlw-macadamia-tetraphylla-identification-fact-sheet
    - HLW *Macadamia ternifolia* identification fact sheet, https://hlw.org.au/download/hlw-macadamia-ternifolia-identification-fact-sheet
    - HLW *Macadamia jansenii* identification fact sheet, https://hlw.org.au/download/hlw-macadamia-jansenii-identification-fact-sheet
- Habitat fact sheet on regional ecosystem 12.3.1: Gallery rainforest on alluvial plains, https://hlw.org.au/download/re-12-3-1-gallery-rainforest-on-alluvial-plains (May 2016)
- Three colouring-in and maths handouts for children, http://www.wildmacadamias.org.au/PDFs/Kids%20macadamia%20activities.pdf
- Twenty-six (26) articles (Nov 2014 to Nov 2017) posted on MCT website (http://www.wildmacadamias.org.au/news-and-projects) and distributed through AMS e-newsletter
- Arbor Age magazine article (Appendix 4)

Outcomes

- Improved ability of local and state governments in Queensland to assess potential for development impact on macadamia habitat;
- Improved understanding and capacity of governments and land managers to address impact of threats to macadamia populations, including habitat fragmentation and climate change;
- Increased community and industry awareness of the status and significance of wild macadamias;
- Increased community capacity to identify and record data on macadamias;
- Improved understanding within the local native nursery industry of the importance of individual tree selection in propagating wild macadamias;
- Increased technical skills and knowledge within the local native nursery industry to propagate macadamias by cutting;
- Substantial contribution to improving understanding of the genetic diversity and relationships between wild populations and individual trees; and
- Increased industry understanding and participation in macadamia conservation.

Monitoring and evaluation

Regular review of project activities was undertaken to ensure completion of milestones, collation of required voluntary contributions and alignment with recovery plan actions.

Oversight and direction to the project was provided by the Macadamia Conservation Committee (coordinated by the Trust), and Committee members contributed directly to project activities when and where possible.

Recommendations

Still Wild about Macadamias significantly progressed understanding of wild macadamias and their conservation needs, however, it has also identified several areas for further or new action.

- continue building awareness within the macadamia industry and the wider community of the status of wild macadamias and the conservation actions required – events and activities conducted at the end of the project still encountered people unaware that macadamias are native to Australia and threatened in the wild
- continue to engage and involve the community and macadamia industry in macadamia conservation utilising a diversity of mechanisms, e.g., citizen science, donations and/or sponsorship, participation in events
- upskilling of the nursery industry and land managers to incorporate research learnings into conservation and land management actions
- provide ongoing support for onground management of local threats – many threats cannot be eliminated within the short to medium term but require long-term commitment and resourcing
- ongoing sampling of macadamia population genetics and analysis to inform conservation priorities, particularly, populations vulnerable to climate change
- undertake research into the impact of seed-predators on recruitment within wild populations – most survey sites showed little or no successful recruitment and plenty of evidence of seed predation
- essential habitat mapping for *M. jansenii*, utilising Queensland Department of Environment and Science endorsed process
- investigate process for legislative and/or planning protection of *M. tetraphylla* in New South Wales

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Intellectual property, commercialisation and confidentiality

No project IP, project outputs, commercialisation or confidentiality issues to report.

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We also acknowledge that the places in which macadamias grow have been nurtured by Australia's First Peoples for tens of thousands of years. We believe the spiritual, cultural and physical consciousness gained through this custodianship is vital to maintaining their future.

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- Dr Bill McDonald
- Dr Michael Powell
- Public and private landholders

Appendices

1. *Macadamia integrifolia* (Queensland Nut) Biology and Distribution in the South East Queensland Bioregion, v1.3 (May 2019)
2. *Macadamia ternifolia* (Gympie Nut) Biology and Distribution in the South East Queensland Bioregion, v1.3 (May 2019)
3. *Macadamia. tetraphylla* (Rough-shelled Bush Nut) Biology and Distribution in the South East Queensland Bioregion, v1.3 (May 2019)
4. Arbor Age article, Apr-May 2018
5. Get Results Gardening, SEQQld Edition, 19 October 2018

Macadamia integrifolia (Queensland Nut) Biology and Distribution in the South East Queensland Bioregion

Version 1.3, Healthy Land and Water 2019

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Attribution

Healthy Land and Water (2019). *Macadamia integrifolia* (Queensland Nut): Biology and Distribution in the South East Queensland Bioregion. Version 1.3. Healthy Land and Water, Brisbane.

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TAXONOMY and STATUS

Scientific Name: *Macadamia integrifolia*

Common Name: Queensland Nut, Bauple Nut, Smooth-shelled Bush Nut

National Status: Vulnerable - *Environmental Protection and Biodiversity Conservation Act 1999*

Queensland Status: Vulnerable - *Nature Conservation Act 1992*

Regional Status: Medium - Burnett-Mary (DERM 2010a); Medium - South East Queensland (DERM 2010b)

DESCRIPTION

Macadamia integrifolia (Queensland Nut) is a perennial, evergreen tree that grows in the mid-storey of lowland subtropical rainforests of south-east Queensland (Powell and Gould 2017, in prep., Gross 1995). *Macadamia integrifolia* is a long-lived species which reaches maturity at around ten years and has a juvenile period of over six years (Queensland CRA/RFA Steering Committee 1997). Trees over 100 years old (planted from wild seed) are known, including the Walter Hill Tree in the City Botanic Gardens, Brisbane, estimated to be 160 years old, and the Jordan Tree on the Gold Coast, thought to be over 140 years old (National Trust, 2018).

Macadamia integrifolia grows to 25m tall and has greyish branchlets dotted with raised lenticels (Hauser and Blok 1992). Trees are often multi-stemmed with small crowns. The simple obovate to narrowly oblong leaves are usually arranged in whorls of three, though occasionally are opposite. Leaves are between 5.5cm and 14cm long by 2.5cm to 6cm wide (Stanley and Ross 2002). The tips of each leaf blade are rounded, finishing with a short sharp point, whilst the base of the leaf tapers to petioles 5 mm to 10mm long (Powell and Gould 2017, in prep.). New leaves are usually light green, though can have a reddish-brown flush.

Creamy-white flowers are arranged in brush-like hanging racemes 10cm to 30cm long. Rounded fruits are green, 2.5cm to 3.5cm wide, and contain a hard, smooth, brown inner shell protecting an edible nut.

Hybridization, leading to mixed morphological traits, has been documented between *M. integrifolia* and *M. ternifolia* (Gympie Nut), and between *M. integrifolia* and *M. tetraphylla* (Rough-shelled Bush Nut) in areas where the species co-occur (Peace 2002).

DISTRIBUTION

Queensland Nut's edible kernel has resulted in its cultivation and widespread planting across Australia (particularly along the east coast), as well as internationally. Indigenous Australians were familiar with the edible properties of *M. integrifolia,* however their role in its dispersal is not well understood.

Queensland Nut's natural distribution, however, is along approximately 300km of south east Queensland's foothills and coastal ranges, from Currumbin Valley in the Gold Coast hinterland (Barry and Thomas 1994) to Mt Bauple north of Gympie (Stanley and Ross 1986). It is more widespread and frequent in the northern half of its range (Powell and Gould 2017, in prep.), where it co-occurs with Gympie Nut (*M. ternifolia*) on the Blackall Range and Samford Valley. In the south of its range, it co-occurs with Rough-shelled Bush Nut (*M. tetraphylla*).

Queensland Nut's distribution pattern is one of clusters of populations, potentially an association with refugial habitats that have arisen from long-term climate cycles, together with limited capacity for dispersal during periods of favorable climate (Powell et al. 2014). Recent phylogenetic analysis of *M. integrifolia* germplasm provides evidence for strong phylogeographic structure with five populations identified. The deep divergence between northern (Mt Bauple to Amamoor Valley) and southern clades indicates historical barriers to seed dispersal in this species (Nock et al. under review, Frontiers in Plant Science).

A few populations occur within National Parks, e.g., Mt Bauple, Nicoll Scrub and Triunia National Parks, however the majority are located on private land, forestry leases and local government reserves.

LIFE HISTORY TRAITS

Population: Powell and Gould (2017, in prep.) estimate the total population size to be between 5,000 – 10,000 mature individuals, located within approximately 60 key populations and with 10-300 mature specimens at each locality. The Amamoor Valley, south west of Gympie, is the centre of the largest cluster of populations and individuals, with potentially more than 10,000 individuals recorded, of which more than half are mature individuals (Neal et al. 2010); this could comprise up to 90% of the total natural population of Queensland Nut.

It is important to note that a substantial number of Queensland Nut populations occur in areas not mapped as remnant vegetation, where stands have been preserved for their ability to produce edible nuts while other native vegetation has been cleared (Powell and Gould 2017, in prep.).

The revised national Recovery Plan (Powell and Gould 2017, in prep.) identifies priority populations within each population cluster based on population size, proximity to remnant vegetation and neighbouring populations, and the presence of other macadamia species. This found that most very high priority populations of Queensland Nut are located on private land, forestry leases, and local government conservation reserves.

Habitat: The Queensland Nut naturally occurs in range of rainforest communities, comprising complex and simple notophyll vine forests, simple microphyll-notophyll vine forest with emergent *Araucaria* and *Argyrodendron*, and also in sclerophyll forests where rainforest is subdominant, its presence mediated by fire (Powell et al. 2010).

The Queensland Herbarium Regional Ecosystem Description Database (REDD v10.1 March 2018) identifies five regional ecosystems (REs) as habitat for *Macadamia integrifolia*: endangered REs 12.3.1 and 12.3.16, and least concern REs: 12.8.3, 12.11.10 and 12.12.16. Powell et al. (2010), however, found that *M. integrifolia* only occurs in a subset of the total range of these RE communities and that at least half the populations occur in other REs though most of these are near the identified RE types, for example in a drier forest type bordering a rainforest gully.

The species occurs in a range of landforms, including hill crests, hill slopes, scree slopes and foot slopes, gullies, benches and terrace plains, with slopes ranging from level to steep (Barry and Thomas, 1994). It is found at a wide range of altitudes, from 5–600 m above sea level (Costello et al 2009). High nutrient alluvial and volcanic soils predominate often with considerable exposure of rock fragments or substrate, mostly basalt and diorite. The surface soils are uniformly dark, slightly acid (pH 5.5–6.5) and varying in texture from clayey-sand through various loams to silty-clay. All sites are well-drained, some excessively so (Barry and Thomas 1994).

The Queensland Nut prefers to grow in mild frost-free areas with a reasonably high rainfall. Planted specimens, however, thrive in orchards and backyards outside of these conditions and there are records of planted specimens bearing fruit as far south as Sydney (Ryan 2006).

Reproduction: Queensland Nut flowers predominantly between August and October, however, is also recorded flowering in January, March and June (Forster et al. 1991) to November (Barry and Thomas 1994; Gross 1995; Stanley and Ross 1986).

Fruit development relies on effective pollination of macadamia flowers. Flowers are pollinated predominantly by the introduced European Honey Bee (*Apis mellifera*) and native *Tetragonula* (previously *Trigona*) species, with *Tetragonula* bees believed to be more efficient pollinators (Heard 1993). Though Queensland Nut is weakly self-compatible, at least in orchard conditions, this results in lower final fruit set compared with cross-pollination (Neal et al. 2010).

Macadamia are renowned for low fruit set. In their study of M. integrifolia fecundity in the wild, Neal et al. (2010) found an average of 80 racemes (flower clusters) were produced by flowering trees, and that the more racemes produced, the higher the probability of fruiting; this significantly decreased for trees located in continuous habitat. Further, Neal et al. (2010) found that fruiting trees only produced on average 2.5 fruit per fruiting tree. This low proportion of fruit set is also well known within commercial orchards, where only 1-2% of all flowers are expected to turn into nutlets (MMI 2018) and fewer than this reach maturity.

In cultivation, Queensland Nut begins to produce what are considered viable nut loads at around 10 years of age (Vock 1989 cited in Blundell 1998), however, in the wild, trees are known to start bearing fruit at three years (Bush Nuts 2016).

Fruits have been recorded from November–January and March–April (Barry and Thomas 1994, Forster et al. 1991), with mature nuts falling to the ground thereafter. Seeds have a viability of 3–6 months.

Seed dispersal is predominantly by gravity and water (Pisanu 2001, O'Connor et al. 2015). Whilst seed predators such as native and introduced mammals, including the introduced Black Rat (*Rattus rattus*), and potentially large seed-eating birds (Sulphur-crested Cockatoo have been observed feeding on orchard trees, L. Gould, pers. comm.), can cause extensive damage to nuts, it is likely they have a role in dispersal (Pisanu 2001). The extent and impact of seed dispersal by Indigenous Australians prior to European settlement is unknown.

Multi-stemming in wild trees occurs in response to stress or damage (Neal 2007, Queensland CRA/RFA Steering Committee 1997), such as that caused by fire (O'Hare et al. 2004, Rosedale 1969).

THREATENING PROCESSES

Known:

- Land clearing for urban development and agriculture (Powell and Gould 2017, in prep.; Ryan 2006; Queensland CRA/RFA Steering Committee 1997).
- Weed invasion – weeds such as Lantana (*Lantana camara*) and Camphor Laurel (*Cinnamomum camphora*), can dominate preferred habitat of the Macadamia Nut, making it difficult for new trees to become established. Lantana and exotic grasses (such as green panic – *Panicum maximum*) at rainforest margins can substantially raise fuel loads and affect both fire intensity and frequency (Costello et al. 2009). Vine weeds such as Cat's claw creeper (*Dolichandra unguis-cati*) and Madeira vine (*Anredera cordifolia*), have demonstrated capacity to invade and establish within intact rainforest, forming a thick groundcover overwhelming understorey vegetation and eventually growing to canopy level, progressively smothering and collapsing mature trees (Powell and Gould 2017, in prep.).

- Wind damage can occur to fruiting trees (weighed down with nuts) that do not have a protective windbreak, resulting in loss of branches or, in some cases, the loss of a whole tree (Ryan 2006).
- Wildfire and inappropriate fire regimes – Queensland Nut is highly susceptible to fire damage (O'Hare et al. 2004; Queensland CRA/RFA Steering Committee 1997; Ryan 2006) although its ability to coppice may mitigate against this damage to some extent.
- Roadside maintenance and infrastructure upgrades (Reynolds 2010; Powell and Gould 2017, in prep.).

Suspected:

- Clearing causing isolation of Queensland Nut trees - increasing susceptibility to wind damage and reducing the availability of natural pollinators (Ryan 2006; Blanche et al. 2006).
- Unmanaged livestock (Powell and Gould 2017, in prep.)
- Compaction of the soil layer around the base of trees, caused by livestock and vehicles, has a deleterious effect on trees by preventing water from penetrating and draining from the soil (Ryan 2006).
- Seed predation by rodents and insects (e.g., fruit spotting bug)
- Loss of small populations through stochastic events
- Decline of population through isolation and edge effects
- Climate change impacts on habitat, phenology (including the initiation of flowering and the maturation of fruit, and potentially that of pollination vectors) and other threats (Powell and Gould 2017, in prep.; Williams et al. 2006).
- Low fruit set and germination
- Loss of genetic diversity through hybridisation with commercial varieties (O'Connor et al. 2015)
- *Phytophthora* root rot (Akinsami 2016)
- Feral pigs (Powell and Gould 2017, in prep.; Ross 2012)
- Pests and diseases from commercial orchards (Powell and Gould 2017, in prep.).

HABITAT ASSESSMENT

Expert(s): Dr Bill McDonald, Dr Catherine Nock, Ms Denise Bond, Mr Ian McConachie (OAM)

Rule(s) for Assigning Habitat Value:

1. Area of assessment confined to South East Queensland Bioregion.
2. Utilisation of regional ecosystems (REs) by the taxon was derived through a spatial intersect of available high precision (post-1974 with a location precision of ≤500m) records with RE mapping produced by the Queensland Herbarium (v10.1). The selected REs were further assessed with regard to the number of intersecting high precision records to determine the significance of individual REs to the species and the resultant list reviewed by the expert panel. During this process, some REs (e.g., 12.11.2, 12.11.5, 12.12.15, 12.11.25) were discounted

by the expert panel as providing viable habitat due to the absence of wetter forest species. The consequent revised list of REs identified as preferred habitat for Queensland Nut is included in Appendix 1.

3. The area of assessment was refined to those RE polygons containing the REs listed in Appendix 1 (in any proportion), with any part occurring ≤600m above sea level and receiving ≥1000m rainfall and located within the subcatchment of a high precision record.

   Within the assessment area, any polygons intersected by a buffered high precision record (with a buffer radius 500m irrespective of precision value) were classed as **Preferred Habitat-Known (PHK)**.

4. **Preferred Habitat – Possible (PHP)** was identified as all other polygons containing the regional ecosystems listed in Rule 2 within the area of assessment identified defined by Rules 1 and 3.

5. **General Habitat-Known (GHK)** and **General Habitat-Possible (GHP)** were determined to be not relevant to the species.

Rule(s) for Assigning Confidence Level:

1. RE polygons selected as **PHK** are assigned a High confidence where these contain the REs 12.3.1a, 12.3.2, 12.3.16, 12.8.3, 12.11.3, 12.11.10, 12.11.24 or 12.12.16 in any proportion. Reason: Known use by the taxon.

2. RE polygons selected as **PHK** are assigned a Medium confidence where these contain the REs 12.9-10.16, 12.11.1, 12.11.3a or 12.12.1 in any proportion. Reason: Known use by the taxon, however, use is restricted to wetter gullies.

3. RE polygons selected as **PHK** are assigned a Low confidence where these contain the RE 12.3.7 in any proportion. Reason: Known use by the taxon, however, use is highly restricted.

4. RE polygons selected as **PHP** are assigned a High confidence where these contain the REs 12.3.1a, 12.3.2, 12.3.16, 12.8.3, 12.11.3, 12.11.10, 12.11.24 or 12.12.16 in any proportion and are located ≤3000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Likely use by the taxon.

5. RE polygons selected as **PHP** are assigned a Medium confidence where these contain the REs 12.9-10.16, 12.11.1, 12.11.3a or 12.12.1 in any proportion, and are located ≤1000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Possible use by the taxon.

6. RE polygons selected as **PHP** are assigned a Low confidence where these contain the RE 12.3.7 and are located ≤1000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Little likelihood of use by the taxon.

A summary of the rules above is provided in Appendix 2.

Overall Confidence:

Species Distribution – High, but will improve with further investigation.

Species Habitat Value Interpretation – Medium, but will improve with further investigation.

Core Habitat:

For the purposes of any Biodiversity Planning Assessment using the Biodiversity Assessment and Mapping Methodology, the experts recommend that Preferred Habitat - Known (High and Medium confidence) and Preferred Habitat - Possible (High confidence) be considered Core Habitat. All planning units identified as such should be attributed with the presence of this taxon.

Other Significant Habitat:

In addition to Core Habitat, the expert panel recommends that Preferred Habitat – Possible (Medium confidence) are areas requiring further investigation to which the precautionary principle should be applied.

A Note on Non-Remnant Habitat:

The expert panel considers that non-remnant vegetation surrounding Preferred Habitat (Known or Possible) of Queensland Nut may be significant for the species and recommends these areas require further investigation to which the precautionary principle should be applied. Further, Queensland Nut trees planted prior to 1940 within cleared landscapes are likely to have been sourced from wild populations and require further investigation; the precautionary principle should also be applied to decisions concerning their management.

DATA SUPPORT

Regional Ecosystems: Queensland Herbarium (2018). Regional Ecosystem – Version 10.1. Department of Natural Resource Management, Brisbane

Landcover: Queensland Department of Natural Resources (2006). Land Cover Change in Queensland 1991-2005, A Statewide Landcover and Trees Study (SLATS) report.

Elevation – Digital Elevation Model: US National Geospatial Intelligence Agency (NGA) and the US National Aeronautics and Space Administration (NASA) (2010). Shuttle Radar Topography Mission (SRTM) Digital Elevation Model.

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Streams: Moreton Bay Waterways and Catchments Partnership and WBM Oceanics (2004). South East Queensland Streams and Catchments.

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Appendix 1: List of regional ecosystems in Preferred category for *Macadamia integrifolia* distribution in the SEQ Bioregion (descriptions from REDD v10.1 March 2018).

- 12.3.1a Complex notophyll vine forest. Typical canopy species include *Castanospermum australe, Elaeocarpus grandis, Grevillea robusta, Cryptocarya obovata, Beilschmiedia obtusifolia, Dysoxylum mollissimum* subsp. *molle, Pseudoweinmannia lachnocarpa, Argyrodendron trifoliolatum, Planchonella australis, Ficus watkinsiana, F. macrophylla* forma *macrophylla, Aphananthe philippinensis, Toona ciliata* and *Syzygium francisii*. Emergent *Eucalyptus grandis* or *Lophostemon confertus* may occur. *Waterhousea floribunda* and *Tristaniopsis laurina* may occur on banks of stream channels. Typical sub canopy species include *Cryptocarya triplinervis, Archontophoenix cunninghamiana, Endiandra pubens, Arytera divaricata, Syzygium moorei* and *Macadamia* spp. Occurs on Quaternary alluvial plains and channels in areas of high rainfall (generally >1300mm). Riverine wetland or fringing riverine wetland.

- 12.3.2 *Eucalyptus grandis +/- E. microcorys, Lophostemon confertus* tall open forest with vine forest understorey ('wet sclerophyll'). Patches of *Eucalyptus pilularis* sometimes present especially in vicinity of sedimentary rocks (e.g. around Palmwoods). Fringing streams and in narrow gullies in high rainfall areas

- 12.3.7 Narrow fringing woodland of *Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana +/- Melaleuca viminalis*. Other species associated with this RE include *Melaleuca bracteata, M. trichostachya, M. linariifolia*. North of Brisbane *Waterhousea floribunda* commonly occurs and may at times dominate this RE. *Melaleuca fluviatilis* occurs in this RE in the north of the bioregion. *Lomandra hystrix* often present in stream beds. Occurs on fringing levees and banks of rivers and drainage lines of alluvial plains throughout the region.

- 12.3.16 Complex notophyll to microphyll vine forest. Typical canopy species include *Aphananthe philippinensis, Argyrodendron sp. (Kin Kin W.D.Francis AQ81198), Argyrodendron trifoliolatum, Diospyros fasciculosa, Drypetes deplanchei, Dysoxylum mollissimum* subsp. *molle, Jagera pseudorhus, Mallotus discolor, Melia azedarach, Mischocarpus pyriformis* subsp. *pyriformis, Planchonella pohlmaniana, Toona ciliata* and *Vitex lignum-vitae*. *Casuarina cunninghamiana* may occur in scattered patches or low densities along channel banks. *Grevillea robusta* commonly occurs south of Maryborough. Emergents of *Araucaria cunninghamii, Eucalyptus tereticornis* and *Lophostemon confertus* may occur. Typical sub-canopy species include *Streblus brunonianus, Cryptocarya triplinervis, Gossia bidwillii, Diospyros australis, Arytera divaricata, Capparis arborea, Cleistanthus cunninghamii* and *Polyalthia nitidissima*. Occurs on Quaternary alluvial plains and channels.

- 12.8.3 Complex notophyll vine forest. Characteristic species include *Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Olea paniculata, Castanospermum australe, Cryptocarya obovata*, *Ficus macrophylla forma macrophylla, Syzygium francisii, Diploglottis australis, Pseudoweinmannia lachnocarpa, Podocarpus elatus, Beilschmiedia obtusifolia, Neolitsea dealbata and Archontophoenix cunninghamiana*. Occurs on Cainozoic igneous rocks, especially basalt <600m altitude

- 12.9-10.16 Microphyll to notophyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Araucaria cunninghamii, Agathis robusta, Backhousia myrtifolia, Cupaniopsis parvifolia, Dendrocnide photinophylla, Rhodosphaera rhodanthema, Flindersia australis, F. xanthoxyla, Drypetes deplanchei, Olea paniculata, Diospyros geminata, Gossia bidwillii, Excoecaria dallachyana* and *Vitex lignum-*

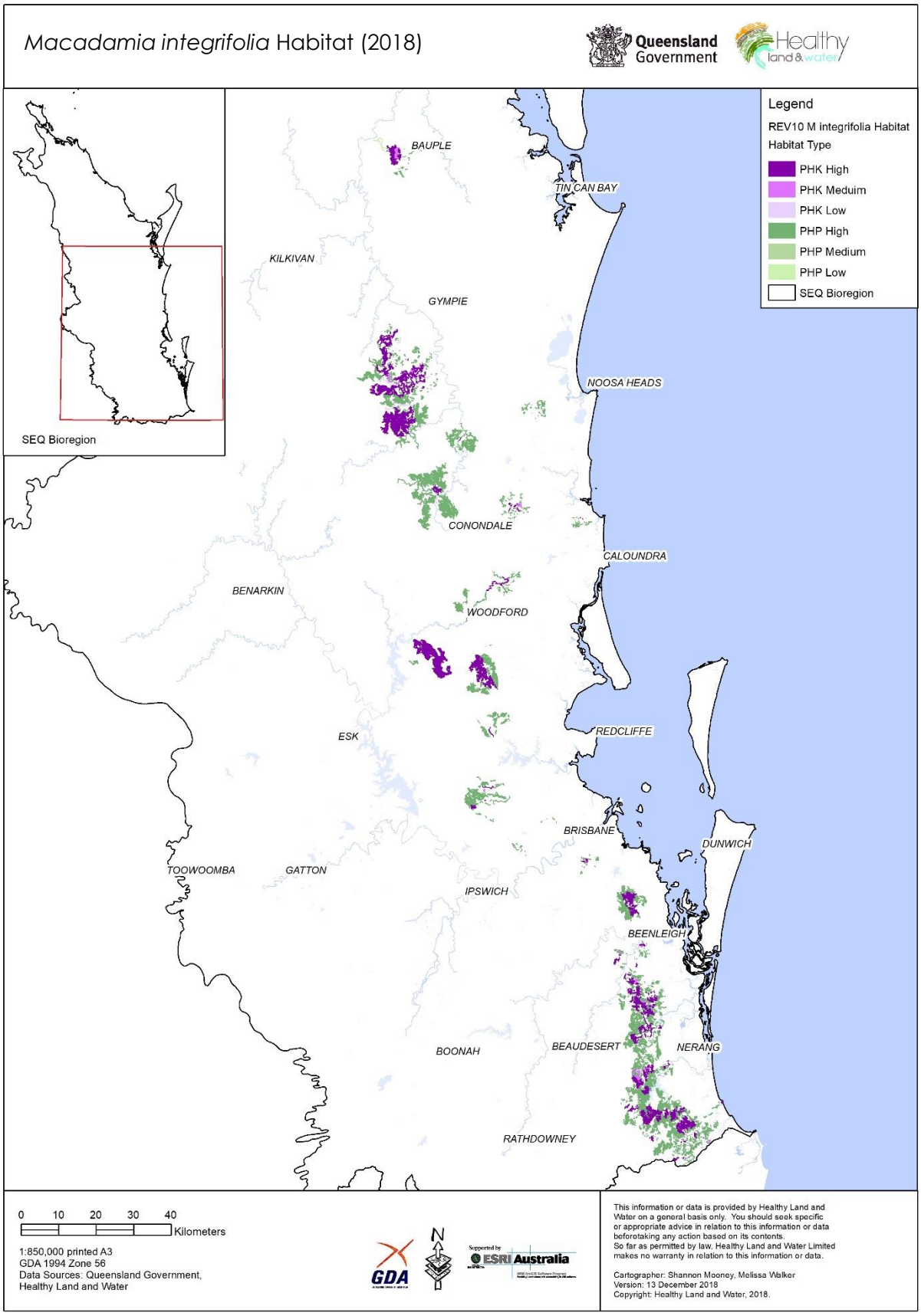
vitae. *Archontophoenix cunninghamiana* often present in gully floors. Occurs on Cainozoic and Mesozoic sediments

- 12.11.1 Evergreen notophyll vine forest and/or *Lophostemon confertus* closed forest. *Archontophoenix cunninghamiana* often present in gully floors. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are characteristic of the type. Occurs in gullies on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics
- 12.11.3 *Eucalyptus siderophloia* and *E. propinqua* open forest +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. biturbinata, E. acmenoides, E. tereticornis, E. moluccana, Angophora leiocarpa, Syncarpia verecunda* with vine forest species and *E. grandis or E. saligna* in gullies. *Eucalyptus pilularis* and *E. tindaliae* sometimes present e.g. mid D'Aguilar Range, Conondale Range. Occurs predominantly on hills and ranges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics
- 12.11.3a *Lophostemon confertus +/- Eucalyptus microcorys, E. carnea, E. propinqua, E. major, E. siderophloia woodland*. Occurs in gullies and exposed ridges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics
- 12.11.10 Notophyll and notophyll/microphyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Backhousia subargentea, Dissiliaria baloghioides, Brachychiton discolor, Beilschmiedia obtusifolia, Diospyros pentamera, Grevillea robusta, Gmelina leichhardtii* and *Ficus macrophylla forma macrophylla*. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics
- 12.11.24 (formerly 12.11.5a) *Eucalyptus carnea, E. tindaliae, Corymbia intermedia* woodland +/- *E. crebra* or *E. siderophloia, Eucalyptus resinifera, Eucalyptus major, E. helidonica, Angophora woodsiana, C. trachyphloia, E. microcorys, Corymbia citriodora* subsp. *variegata*, *C. henryi*. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics usually at altitudes <300 metres
- 12.12.1 Notophyll and notophyll/microphyll vine forest, sometimes with *Archontophoenix cunninghamiana* and/or *Lophostemon confertus* closed forest. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are diagnostic of the type and *Pleioluma queenslandica* is common in the northern half of the bioregion. *Araucaria cunninghamii* is often present on margins. Occurs in gullies on Mesozoic to Proterozoic igneous rocks especially granite and rhyolite
- 12.12.16 Notophyll vine forest. Characteristic species include *Araucaria bidwillii, A. cunninghamii, Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Backhousia subargentea, Brachychiton discolor, Beilschmiedia obtusifolia, Diospyros pentamera, Grevillea robusta, Gmelina leichhardtii, Ficus macrophylla forma macrophylla* and *Sloanea woollsii*. *Eucalyptus* spp. especially *E. siderophloia, E. propinqua* and *E. grandis* may be present as emergents. Occurs on Mesozoic to Proterozoic igneous rocks

Appendix 2: Cross-check of Habitat Value and Confidence Rule-sets for *Macadamia integrifolia* (categories designated as Core Habitat are shaded).

Habitat Value	**High**	**Medium**	**Low**
PHK	Regional ecosystems 12.3.1a, 12.3.2, 12.3.16, 12.8.3, 12.11.3, 12.11.10, 12.11.24, or 12.12.16; AND Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND ≤500m from a high precision record	Regional ecosystems 12.9-10.16, 12.11.1, 12.11.3a or 12.12.1; AND Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND ≤500m from a high precision record	Regional ecosystem 12.3.7; AND Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND ≤500m from a high precision record
PHP	Regional ecosystems 12.3.1a, 12.3.2, 12.3.16, 12.8.3, 12.11.3, 12.11.10, 12.11.24 and/or 12.12.16; AND Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤3000m from a high precision record	Regional ecosystems 12.9-10.16, 12.11.1 12.11.3a and/or 12.12.1; AND Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤1000m from a high precision record	Regional ecosystem 12.3.7; AND Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤1000m from a high precision record
GHK			

Appendix 3: Preferred and General Habitat Map for *Macadamia integrifolia* in the SEQ Bioregion



Macadamia ternifolia (Gympie Nut) Biology and Distribution in the South East Queensland Bioregion

Version 1.3, Healthy Land and Water 2019

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This document was developed by Healthy Land and Water Ltd with support from the Queensland and Australian Governments, Macadamia Conservation Trust and species experts from across the South East Queensland Bioregion. Biological and distribution information was sourced from published and unpublished works and refined with the direct input of available species experts. Publicly available and private data sources were accessed for species occurrence records.

Attribution

Healthy Land and Water (2019). *Macadamia ternifolia* (Gympie Nut): Biology and Distribution in the South East Queensland Bioregion. Version 1.3. Healthy Land and Water, Brisbane.

Acknowledgements

The contributions of members of the expert panel were invaluable in defining habitat and developing the habitat mapping rules. Healthy Land and Water would like to acknowledge the generous support provided by experts through all stages of development of the document and the resultant habitat mapping.

Within Healthy Land and Water, the contributions of Melissa Walker (data collation and analysis), Shannon Mooney (GIS interpretation) and Liz Gould (profile development and project coordination) are acknowledged.

Disclaimer

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Table Contents

TAXONOMY and STATUS

Scientific Name: *Macadamia ternifolia*

Common Name: Gympie Nut

National Status: Vulnerable - *Environmental Protection and Biodiversity Conservation Act 1999*

Queensland Status: Vulnerable - *Nature Conservation Act 1992*

Regional Status: Low - Burnett-Mary (DERM 2010a); Low - South East Queensland (DERM 2010b)

DESCRIPTION

Macadamia ternifolia (Gympie Nut) is a long-lived, evergreen tree that grows in the mid-storey of lowland subtropical rainforests of south-east Queensland (Powell and Gould 2017 in prep., Gross 1995). It is a long-lived species which reaches maturity at around ten years and has a juvenile period of over six years (Queensland CRA/RFA Steering Committee 1997).

Macadamia ternifolia grows to 18m tall and has brown branchlets dotted with raised lenticels (Hauser and Blok 1992). Trees are often multi-stemmed with small crowns. The simple narrow-oblong to narrow elliptical leaves are usually arranged in whorls of three. Leaves are between 10cm and 12cm long and 2.5cm or more wide (Stanley and Ross 2002). The apex of each leaf blade tapers to a sharp point, whilst the wedge-shaped base of the leaf tapers to petioles 3 mm to 13mm long (Powell and Gould 2017, in prep.). Leaf margins are coarsely and irregularly serrate, with new leaves pinkish red (Stanley and Ross 2002).

Pinkish or cream flowers are arranged in brush-like hanging racemes 4cm to 20cm long. Rounded fruits are greyish, 1.5cm to 2cm wide, and contain a hard, smooth, brown inner shell protecting a cyanogenic, inedible nut.

Hybridization, leading to mixed morphological traits, has been documented between *M. ternifolia* and Queensland Nut (*M. integrifolia*) in areas where the species co-occur (Peace, 2002).

DISTRIBUTION

Macadamia ternifolia naturally occurs along the coastal lowlands and ranges of south east Queensland, occurring from Mt Nebo, northwest of Brisbane, to Goomboorian, north of Gympie (Powell and Gould 2017, in prep.). It co-occurs with *M. integrifolia* on the Blackall Range and Samford Valley.

Macadamia ternifolia's distribution pattern is one of clusters of small populations, within the forest matrix or along riparian zones (Powell and Gould 2017, in prep.), along a range of topographic positions.

Several populations occur within National Parks, e.g., Mount Pinbarren, D'Aguilar (Boombana section, Mt Glorious), Mapleton Falls, Kondalilla, Triunia and Conondale National Parks (Costello et al. 2009), however the majority occur on private land, forestry leases and in local government reserves.

LIFE HISTORY TRAITS

Population: Powell and Gould (2017, in prep.) estimate the total population size to be between 1,500 – 2,500 mature individuals, located within approximately 60 key populations, with an average of 5-25 mature specimens at each locality and several populations of 25-100 individuals.

Approximately 20% of known *M. ternifolia* populations occur in areas not mapped as remnant vegetation, in areas where stands have been preserved, but other native vegetation has been cleared (Powell and Gould 2017, in prep.).

The revised national Recovery Plan (Powell and Gould 2017, in prep.) identifies priority populations within each population cluster based on population size, proximity to remnant vegetation and neighbouring populations, and the presence of other macadamia species. This found that the majority of very high priority populations of *M. ternifolia* are located on private land, forestry leases, and local government reserves.

Habitat: *Macadamia ternifolia* naturally occurs in a range of rainforest communities, comprising complex and simple notophyll vine forests, simple microphyll-notophyll vine forest with emergent *Araucaria* and *Argyrodendron*, and frequently within riparian habitats (Powell and Gould 2017, in prep.). The Queensland Herbarium Regional Ecosystem Description Database (REDD, v10.1 March 2018) identifies two regional ecosystems (REs) as *M. ternifolia* habitat: endangered REs 12.3.1a and 12.3.16. The species' revised Recovery Plan (Powell and Gould 2017, in prep.) however, recent evidence of the species occurring in a far greater range of REs, including RE 12.8.3, 12.11.10, 12.12.1 and 12.12.16 (Powell et al. 2014).

The species occurs in a range of landforms, including scree slopes, foot slopes, gullies, benches and riverine terraces. Preferred soils are well drained, typically alluvial or volcanic derived basaltic krasnozems, with significant surface exposure of rock fragments (Costello et al. 2009). It is found in a wide range of altitudes, from 15m to 700m above sea level, and prefers higher rainfall and mild-frost or frost-free areas.

Reproduction: *Macadamia ternifolia* flowers predominantly between June and August, with fruiting occurring in March and April (Powell and Gould 2017, in prep.). Heard (1993) found that *M. integrifolia* flowers are pollinated during the day, predominantly by the introduced European Honey Bee (*Apis mellifera*) and native *Tetragonula* (previously *Trigona*) species, with *Tetragonula* bees believed to be more efficient pollinators, and this may be the case also for *M. ternifolia*.

Seeds have a viability of 1–6 months and are dispersed predominantly by gravity, streams and rodents. Seedlings are rarely recorded (Barry and Thomas 1994).

Multi-stemming occurs in response to stress or damage (Neal 2007, Queensland CRA/RFA Steering Committee 1997), such as that caused by fire (O'Hare et al. 2004, Rosedale 1969).

THREATENING PROCESSES

Known:

- Land clearing for urban development and agriculture, particularly along riverine corridors (Powell and Gould 2017, in prep.; Ryan 2006; Queensland CRA/RFA Steering Committee 1997).
- Weed invasion – weeds such as Lantana (*Lantana camara*) and Camphor Laurel (*Cinnamomum camphora*), can dominate preferred habitat of the Macadamia Nut, making it difficult for new trees to become established. Lantana and exotic grasses (such as green panic – *Panicum maximum*) at rainforest margins can substantially raise fuel loads and affect

both fire intensity and frequency (Costello et al. 2009). Vine weeds such as Cat's claw creeper (*Dolichandra unguis-cati*) and Madeira vine (*Anredera cordifolia*), have demonstrated capacity to invade and establish within intact rainforest, forming a thick groundcover overwhelming understorey vegetation and eventually growing to canopy level, progressively smothering and collapsing mature trees (Powell and Gould 2017, in prep.).

- Loss of genetic viability due to a lack of connectivity between populations and a lack of pollinators and dispersers (Costello et al. 2009)
- Wildfire and inappropriate fire regimes – *M. ternifolia* is highly susceptible to fire damage (O'Hare et al. 2004; Queensland CRA/RFA Steering Committee 1997; Ryan 2006).

Suspected:

- Clearing causing isolation - increasing susceptibility to wind damage and reducing the availability of natural pollinators (Ryan 2006; Blanche et al. 2006).
- Unmanaged livestock (Powell and Gould 2017, in prep.)
- Compaction of the soil layer around the base of trees, caused by livestock and vehicles, has a deleterious effect on trees by preventing water from penetrating and draining from the soil (Ryan 2006).
- Seed predation by rodents and insects (e.g., fruit spotting bug)
- Loss of small populations through stochastic events
- Decline of population through isolation and edge effects
- Climate change impacts on habitat, phenology (including the initiation of flowering and the maturation of fruit, and potentially that of pollination vectors) and other threats (Powell and Gould 2017, in prep.; Williams et al. 2006).
- Low fruit set and germination
- Loss of genetic diversity through hybridisation with commercial varieties (O'Connor et al. 2015)
- Phytophthora root rot (Akinsami 2016)
- Feral pigs (Powell and Gould 2017, in prep.; Ross 2012)
- Pests and diseases from commercial orchards (Powell and Gould 2017, in prep.).

HABITAT ASSESSMENT

Expert(s): Ms Denise Bond, Mr Ian McConachie (OAM)

Rule(s) for Assigning Habitat Value:

1. Area of assessment confined to South East Queensland Bioregion.
2. Area of assessment further restricted to:

   a) within the South East Queensland Natural Resource Management (NRM) region, subcatchments north of and including Moggill Creek subcatchment, and

   b) within the Burnett-Mary NRM region, the Mary River catchment.

3. Utilisation of regional ecosystems (REs) by the taxon was derived through a spatial intersect of available high precision (post-1974 with a location precision of ≤500m) records with RE mapping produced by the Queensland Herbarium (v10.1). Selected REs were further analysed with regard to frequency and area of buffered point (500m) to determine the significance of individual REs to the species, and the resultant list reviewed by the expert panel. The consequent complete list of REs identified as preferred habitat for Rough-shelled Bush Nut is included in Appendix 1.

4. Area of assessment was refined to RE polygons containing REs listed in Appendix 1 (in any proportion) and with any part occurring ≤700m above sea level and ≥1000m rainfall and located within the subcatchment of a high precision record.

5. Within the assessment area, any RE polygons intersected by a buffered high precision record (with a buffer radius 500m irrespective of precision value) were classed as **Preferred Habitat-Known (PHK)**.

6. **Preferred Habitat – Possible (PHP)** was identified as all other polygons containing the REs listed in Rule 3 within the area of assessment (as defined by Rules 1, 2 and 4).

7. **General Habitat-Known (GHK)** and **General Habitat-Possible (GHP)** were determined to be not relevant to the species.

Rule(s) for Assigning Confidence Level:

1. RE polygons selected as **PHK** are assigned a High confidence. Reason: Known use by the taxon.

2. RE polygons selected as **PHP** are assigned a High confidence where these contain the REs 12.3.1a, 12.8.3, 12.9-10.16, 12.11.1, 12.11.2, 12.11.3, 12.11.10, 12.12.1, 12.12.15, 12.12.16 or 12.12.23 (in any proportion) and are located ≤3000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Likely use by the taxon.

3. RE polygons selected as **PHP** are assigned a Medium confidence where these contain the REs 12.3.16, 12.8.13 or 12.11.16 (in any proportion) and are located ≤1000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Possible use by the taxon.

4. RE polygons selected as **PHP** are assigned a Low confidence where these contain RE 12.11.9 (in any proportion) and are located ≤1000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Low likelihood of use by the taxon.

A summary of the rules above is provided in Appendix 2.

Overall Confidence:

Species Distribution – High, but will improve with further investigation.

Species Habitat Value Interpretation – Medium, but will improve with further investigation.

Core Habitat:

For the purposes of any Biodiversity Planning Assessment using the Biodiversity Assessment and Mapping Methodology, the experts recommend that Preferred Habitat - Known (High confidence) and Preferred Habitat - Possible (High confidence) be considered Core Habitat. All planning units identified as such should be attributed with the presence of this taxon.

Other Significant Habitat:

In addition to Core Habitat, the expert panel recommends that Preferred Habitat - Possible (Medium confidence) are areas requiring further investigation to which the precautionary principle should be applied.

A Note on Non-Remnant Habitat:

The expert panel considers that non-remnant vegetation surrounding Preferred Habitat (Known or Possible) of *M. ternifolia* may be significant for the species and recommends these areas require further investigation to which the precautionary principle should be applied. Further, *M. ternifolia* trees planted prior to 1940 within cleared landscapes are likely to have been sourced from wild populations and require further investigation; the precautionary principle should also be applied to decisions concerning their management.

DATA SUPPORT

Regional Ecosystems: Queensland Herbarium (2018). Regional Ecosystem – Version 10.1. Department of Natural Resource Management, Brisbane

Landcover: Queensland Department of Natural Resources (2006). Land Cover Change in Queensland 1991-2005, A Statewide Landcover and Trees Study (SLATS) report.

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Appendix 1: List of regional ecosystems in Preferred category for *Macadamia ternifolia* distribution in the SEQ Bioregion (descriptions from REDD v10.1 March 2018).

- 12.3.1a Complex notophyll vine forest. Typical canopy species include *Castanospermum australe, Elaeocarpus grandis, Grevillea robusta, Cryptocarya obovata, Beilschmiedia obtusifolia, Dysoxylum mollissimum* subsp. *molle, Pseudoweinmannia lachnocarpa, Argyrodendron trifoliolatum, Planchonella australis, Ficus watkinsiana, F. macrophylla* forma *macrophylla, Aphananthe philippinensis, Toona ciliata* and *Syzygium francisii*. Emergent *Eucalyptus grandis* or *Lophostemon confertus* may occur. *Waterhousea floribunda* and *Tristaniopsis laurina* may occur on banks of stream channels. Typical sub canopy species include *Cryptocarya triplinervis, Archontophoenix cunninghamiana, Endiandra pubens, Arytera divaricata, Syzygium moorei* and *Macadamia* spp. Occurs on Quaternary alluvial plains and channels in areas of high rainfall (generally >1300mm). Riverine wetland or fringing riverine wetland.
- 12.3.16 Complex notophyll to microphyll vine forest. Typical canopy species include Aphananthe philippinensis, Argyrodendron sp. (Kin Kin W.D.Francis AQ81198), Argyrodendron trifoliolatum, Diospyros fasciculosa, Drypetes deplanchei, Dysoxylum mollissimum subsp. molle, Jagera pseudorhus, Mallotus discolor, Melia azedarach, Mischocarpus pyriformis subsp. pyriformis, Planchonella pohlmaniana, Toona ciliata and Vitex lignum-vitae. Casuarina cunninghamiana may occur in scattered patches or low densities along channel banks. Grevillea robusta commonly occurs south of Maryborough. Emergents of Araucaria cunninghamii, Eucalyptus tereticornis and Lophostemon confertus may occur. Typical sub-canopy species include Streblus brunonianus, Cryptocarya triplinervis, Gossia bidwillii, Diospyros australis, Arytera divaricata, Capparis arborea, Cleistanthus cunninghamii and Polyalthia nitidissima. Occurs on Quaternary alluvial plains and channels.
- 12.8.3 Complex notophyll vine forest. Characteristic species include *Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Olea paniculata, Castanospermum australe, Cryptocarya obovata*, *Ficus macrophylla forma macrophylla, Syzygium francisii, Diploglottis australis, Pseudoweinmannia lachnocarpa, Podocarpus elatus, Beilschmiedia obtusifolia, Neolitsea dealbata and Archontophoenix cunninghamiana*. Occurs on Cainozoic igneous rocks, especially basalt <600m altitude.
- 12.8.13 Microphyll and microphyll/notophyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Araucaria cunninghamii, A. bidwillii, Cupaniopsis parvifolia, Dendrocnide photinophylla, Rhodosphaera rhodanthema, Flindersia australis, F. schottiana, F. xanthoxyla, Drypetes deplanchei, Olea paniculata, Diospyros geminata, Gossia bidwillii, Excoecaria dallachyana, Pleiogynium timorense* (north of bioregion) and *Vitex lignum-vitae*. *Argyrodendron trifoliolatum* sometimes present especially in subregion 6. Occurs on Cainozoic igneous rocks, especially basalt.
- 12.9-10.16 Microphyll to notophyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Araucaria cunninghamii, Agathis robusta, Backhousia myrtifolia, Cupaniopsis parvifolia, Dendrocnide photinophylla, Rhodosphaera rhodanthema, Flindersia australis, F. xanthoxyla, Drypetes deplanchei, Olea paniculata, Diospyros geminata, Gossia bidwillii, Excoecaria dallachyana* and *Vitex lignum-vitae*. *Archontophoenix cunninghamiana* often present in gully floors. Occurs on Cainozoic and Mesozoic sediments.
- 12.11.1 Evergreen notophyll vine forest and/or *Lophostemon confertus* closed forest. *Archontophoenix cunninghamiana* often present in gully floors. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are characteristic of the type. Occurs in gullies on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics.

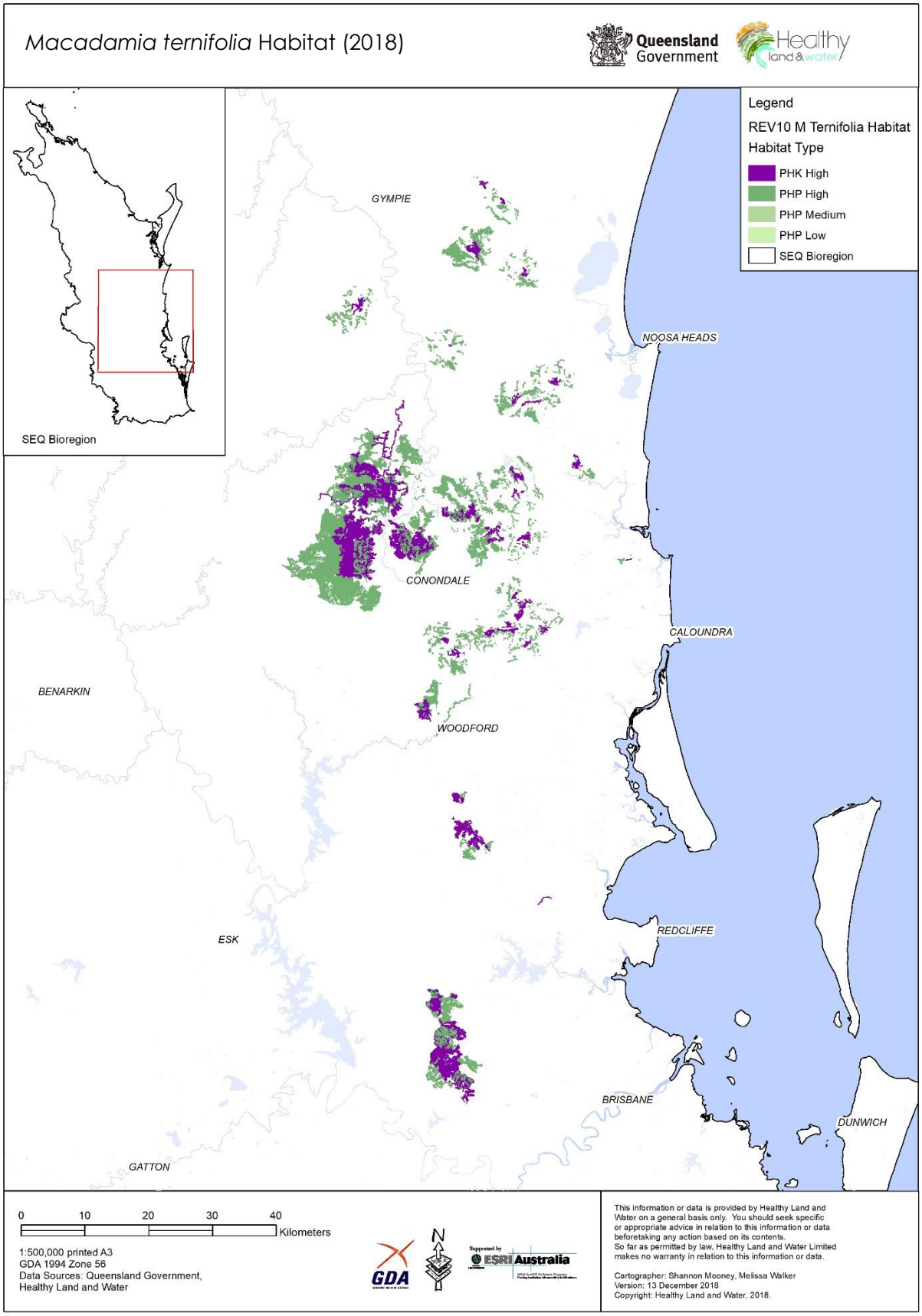
- 12.11.2 Tall open forest with vine forest understorey ('wet sclerophyll'). Canopy species include *Eucalyptus saligna* subsp. *saligna or E. grandis, E. microcorys, Corymbia intermedia* and *Lophostemon confertus.* Characteristic understorey species include *Caldcluvia paniculosa, Pittosporum undulatum, Synoum glandulosum* subsp. *glandulosum* and *Cryptocarya microneura*. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics.
- 12.11.3 *Eucalyptus siderophloia* and *E. propinqua* open forest +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. biturbinata, E. acmenoides, E. tereticornis, E. moluccana, Angophora leiocarpa, Syncarpia verecunda* with vine forest species and *E. grandis or E. saligna* in gullies. *Eucalyptus pilularis* and *E. tindaliae* sometimes present e.g. mid D'Aguilar Range, Conondale Range. Occurs predominantly on hills and ranges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics.
- 12.11.9 Open forest to woodland with *Eucalyptus tereticornis.* Includes both *E. tereticornis subsp. tereticornis* and *E. tereticornis subsp. basaltica.* Other canopy species include *Eucalyptus biturbinata, E. melliodora, Corymbia intermedia, E. longirostrata, E. eugenioides, Allocasuarina torulosa, E. moluccana, E. saligna, E. siderophloia* and *Angophora subvelutina*. Occurs on ridges and upper slopes especially at higher altitudes on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. These occurrences are often associated with small areas of intermediate and basic volcanic rocks. Minor occurrences on low coastal ridges and upper slopes.
- 12.11.10 Notophyll and notophyll/microphyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Backhousia subargentea, Dissiliaria baloghioides, Brachychiton discolor, Beilschmiedia obtusifolia, Diospyros pentamera, Grevillea robusta, Gmelina leichhardtii* and *Ficus macrophylla forma macrophylla*. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics.
- 12.11.16 Eucalyptus cloeziana +/- E. propinqua, E. acmenoides, E. microcorys and E. grandis open forest. Understory is generally shrubby +/- vine forest species. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics, especially phyllite of the Kin Kin Beds.
- 12.12.1 Notophyll and notophyll/microphyll vine forest, sometimes with *Archontophoenix cunninghamiana* and/or *Lophostemon confertus* closed forest. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are diagnostic of the type and *Pleioluma queenslandica* is common in the northern half of the bioregion. *Araucaria cunninghamii* is often present on margins. Occurs in gullies on Mesozoic to Proterozoic igneous rocks especially granite and rhyolite.
- 12.12.15 *Corymbia intermedia +/- Eucalyptus propinqua, E. siderophloia, E. microcorys, Lophostemon confertus.* Other canopy species include *E. acmenoides, E. moluccana, Angophora subvelutina* and occasional vine forest species. Patches of *Eucalyptus pilularis* sometimes present. Occurs on Mesozoic to Proterozoic igneous rocks.
- 12.12.16 Notophyll vine forest. Characteristic species include *Araucaria bidwillii, A. cunninghamii, Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Backhousia subargentea, Brachychiton discolor, Beilschmiedia obtusifolia, Diospyros pentamera, Grevillea robusta, Gmelina leichhardtii, Ficus macrophylla forma macrophylla* and *Sloanea woollsii. Eucalyptus* spp. especially *E. siderophloia, E. propinqua* and *E. grandis* may be present as emergents. Occurs on Mesozoic to Proterozoic igneous rocks.
- 12.12.23 *Eucalyptus tereticornis* subsp. *tereticornis or E. tereticornis* subsp. *basaltica +/- E. eugenioides* woodland on crests, upper slopes and elevated valleys and plains on Mesozoic to Proterozoic igneous rocks.

Appendix 2: Cross-check of Habitat Value and Confidence Rule-sets for *Macadamia ternifolia* (categories designated as Core Habitat are shaded).

Habitat Value	**High**	**Medium**	**Low**
PHK	Regional ecosystems identified in Rule3; AND Within the SEQNRM region, north of and including Moggill Creek subcatchment; OR Within the Mary River catchment of the Burnett-Mary NRM region; AND Altitude ≤700m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND ≤500m of a high precision record.		
PHP	Regional ecosystems 12.3.1a, 12.8.3, 12.9-10.16, 12.11.1, 12.11.2, 12.11.3, 12.11.10, 12.12.1, 12.12.15, 12.12.16 or 12.12.23; AND Within the SEQNRM region, north of and including Moggill Creek subcatchment; OR Within the Mary River catchment of the Burnett-Mary NRM region; AND	Regional ecosystems 12.3.16, 12.8.13 or 12.11.16; AND Within the SEQNRM region, north of and including Moggill Creek subcatchment; OR Within the Mary River catchment of the Burnett-Mary NRM region; AND Altitude ≤700m; AND	Regional ecosystems 12.11.9; AND Within the SEQNRM region, north of and including Moggill Creek subcatchment; OR Within the Mary River catchment of the Burnett-Mary NRM region; AND Altitude ≤700m; AND

	Altitude ≤700m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤3000m from a high precision record.	Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤1000m from a high precision record.	Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤1000m from a high precision record.
GHK			

Appendix 3: Preferred and General Habitat Map for *Macadamia ternifolia* in the SEQ Bioregion



Macadamia tetraphylla (Rough-shelled Bush Nut) Biology and Distribution in the South East Queensland Bioregion

Version 1.3, Healthy Land and Water 2019

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This document was developed by Healthy Land and Water Ltd with support from the Queensland and Australian Governments, Macadamia Conservation Trust and species experts from across the South East Queensland Bioregion. Biological and distribution information was sourced from published and unpublished works and refined with the direct input of available species experts. Publicly available and private data sources were accessed for species occurrence records.

Attribution

Healthy Land and Water (2019). *Macadamia tetraphylla* (Rough-shelled Bush Nut): Biology and Distribution in the South East Queensland Bioregion. Version 1.3. Healthy Land and Water, Brisbane.

Acknowledgements

The contributions of members of the expert panel were invaluable in defining habitat and developing the habitat mapping rules. Healthy Land and Water would like to acknowledge the generous support provided by experts through all stages of development of the document and the resultant habitat mapping.

Within Healthy Land and Water, the contributions of Melissa Walker (data collation and analysis), Shannon Mooney (GIS interpretation) and Liz Gould (profile development and project coordination) are acknowledged.

Disclaimer

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Table Contents

TAXONOMY and STATUS

Scientific Name: *Macadamia tetraphylla*

Common Name: Rough-shelled Bush Nut

National Status: Vulnerable - *Environmental Protection and Biodiversity Conservation Act 1999*

Queensland Status: Vulnerable - *Nature Conservation Act 1992*

New South Wales Status: Vulnerable – *Biodiversity Conservation Act 2016*

Regional Status: Medium - South East Queensland (DERM 2010)

DESCRIPTION

Macadamia tetraphylla (Rough-shelled Bush Nut) is a long-lived, perennial, evergreen tree that grows in the mid-storey of lowland subtropical rainforests of northern NSW and south-east Queensland (Powell and Gould 2017 in prep.). It is estimated to have a lifespan of over 100 years, with a juvenile period greater than six years (Queensland CRA/RFA Steering Committee 1997).

Macadamia tetraphylla grows to 18m tall and has greyish-brown branchlets dotted with pale elongated lenticels (Hauser and Blok 1992). Trees are often multi-stemmed with small crowns. The simple oblong lanceolate leaves are usually arranged in whorls of four, though occasionally are in whorls of three or five leaves. Leaves are between 6cm and 20cm long by 2cm to 4cm wide (Stanley and Ross 2002). Each leaf blade has sharply serrated margins and a pointed tip, whilst the base of the leaf tapers to petioles 2mm to 8mm long (Powell and Gould 2017, in prep.). New leaves are bright red in colour.

Pinkish-purple flowers are arranged in brush-like hanging racemes 15cm to 45cm long. Rounded fruits are greyish-green, 2cm to 3.5cm wide, and contain a hard, bumpy or rough, brown inner shell protecting an edible nut.

Hybridization, leading to mixed morphological traits, has been documented between *M. tetraphylla* and *M. integrifolia* (Queensland Nut) in areas where the species co-occur (Peace 2002).

DISTRIBUTION

Macadamia tetraphylla's edible kernel has resulted in its cultivation and planting in backyards and orchards across Australia, particularly along the east coast, and also internationally. Indigenous Australians were familiar with the edible properties of *M. tetraphylla,* however their role in its dispersal is not well understood.

Its natural distribution, however, is along the foothills and coastal ranges of south east Queensland, from Mt Cotton, south of Brisbane, to the Richmond River in northern New South Wales (Powell and Gould 2017, in prep.). In Queensland, it co-occurs and produces hybrids with *M. integrifolia* (Peace 2002). It occurs on moderate to steep hillslopes on alluvial soils at well-drained sites (Queensland CRA/RFA Steering Committee 1997) and at altitudes 10m to 460 m above sea level (Barry and Thomas 1994).

Macadamia tetraphylla is distributed in clusters of populations, potentially an association with refugial habitats that have arisen from long-term climate cycles, together with limited capacity for dispersal during periods of favorable climate (Powell et al. 2014).

Several populations occur within National Parks, e.g., Lamington, Mt Warning, Nicoll Scrub and Springbrook (Natural Bridge and Mt Cougal sections) National Parks, however, the majority of populations occur on private land and local government reserves (Queensland CRA/RFA Steering Committee 1997).

LIFE HISTORY TRAITS

Population: Powell and Gould (2017, in prep.) estimate the total population size to be between 1,500 – 3,000 mature individuals, located within approximately 60 key populations and with 10-100 mature specimens at each locality.

The currently recorded extent of occupied habitat is approximately 750 hectares, however, a substantial number of *M. tetraphylla* populations occur in areas not mapped as remnant vegetation; areas where stands of trees have been preserved, but other native vegetation has been cleared (Powell and Gould 2017, in prep.).

The revised national Recovery Plan (Powell and Gould 2017, in prep.) identifies priority populations within four population clusters, based on population size, proximity to remnant vegetation and neighbouring populations, and the presence of other macadamia species. Only one of these clusters is in Queensland and the majority of very high priority populations within this are located on private land and in local government conservation reserves.

Habitat: *Macadamia tetraphylla* naturally occurs in several vegetation communities, including complex notophyll vine forest, littoral rainforest and wet sclerophyll forests (Powell and Gould 2017, in prep.). The Queensland Herbarium Regional Ecosystem Description Database (REDD, v10.1 March 2018) identifies three regional ecosystems (REs) as habitat for the species: 12.8.3, 12.11.10 and 12.12.16. High priority populations are noted in the species' revised Recovery Plan (Powell and Gould 2017, in prep.), as occurring in only two of these REs, 12.8.3 and 12.11.10.

Reproduction: *Macadamia tetraphylla* flowers between August and October and may take 4-5 years to flower (Saunders 2018) and longer to produce fruit. Fruiting occurs between January and April and fruit can take up to nine months to mature (Saunders 2018), falling to the ground from March (Hauser and Blok 1992). Pollination of *M. tetraphylla* has not been studied, however, may be similar to that of *M. integrifolia,* for which Heard (1993) found that flowers are pollinated during the day, predominantly by the introduced European Honey Bee (*Apis mellifera*) and native *Tetragonula* (previously *Trigona*) species, with *Tetragonula* bees believed to be more efficient pollinators.

Seed dispersal is predominantly by gravity and water (Pisanu 2001, O'Connor et al. 2015). Whilst seed predators such as native and introduced mammals, including the introduced Black Rat (*Rattus rattus*), and potentially large seed-eating birds (Sulphur-crested Cockatoo have been observed feeding on orchard trees, L. Gould, pers. comm.), can cause extensive damage to nuts, it is likely they have a role in dispersal (Pisanu 2001). The extent and impact of seed dispersal by Indigenous Australians prior to European settlement is unknown.

Nuts germinate within a period of two weeks and the seed remains viable for a period of a few weeks to six months. Multi-stemming in wild trees occurs in response to stress or damage (Neal 2007, Queensland CRA/RFA Steering Committee 1997), such as that caused by fire (O'Hare et al. 2004, Rosedale 1969).

THREATENING PROCESSES

Known:

- Land clearing for urban development and agriculture (Powell and Gould 2017, in prep.; Reynolds 2010; Queensland CRA/RFA Steering Committee 1997).
- Weed invasion – weeds such as Lantana (*Lantana camara*) and Camphor Laurel (*Cinnamomum camphora*), can dominate preferred habitat of the Macadamia Nut, making it difficult for new trees to become established. Lantana and exotic grasses (such as green panic – *Panicum maximum*) at rainforest margins can substantially raise fuel loads and affect both fire intensity and frequency (Costello et al. 2009). Vine weeds such as Cat's claw creeper (*Dolichandra unguis-cati*) and Madeira vine (*Anredera cordifolia*), have demonstrated capacity to invade and establish within intact rainforest, forming a thick groundcover overwhelming understorey vegetation and eventually growing to canopy level, progressively smothering and collapsing mature trees (Powell and Gould 2017, in prep.).
- Wind damage can occur to fruiting trees (weighed down with nuts) that do not have a protective windbreak, resulting in loss of branches or, in some cases, the loss of a whole tree.
- Wildfire and inappropriate fire regimes – Rough-shelled Bush Nut is highly susceptible to fire damage (O'Hare et al. 2004; Queensland CRA/RFA Steering Committee 1997; NSW NPWS 2002; Powell and Gould 2017, in prep.).
- Roadside maintenance and infrastructure upgrades (Powell and Gould 2017, in prep.; NSW NPWS 2002).

Suspected:

- Clearing causing isolation of Rough-shelled Bush Nut trees - increasing susceptibility to wind damage and reducing the availability of natural pollinators (Blanche et al. 2006).
- Unmanaged livestock (Powell and Gould 2017, in prep.; NSW NPWS 2002)
- Compaction of the soil layer around the base of trees, caused by livestock and vehicles, has a deleterious effect on trees by preventing water from penetrating and draining from the soil.
- Seed predation by rodents and insects (e.g., fruit spotting bug)
- Loss of small populations through stochastic events (NSW NPWS 2002)
- Decline of population through isolation and edge effects (NSW NPWS 2002)
- Climate change impacts on habitat, phenology (including the initiation of flowering and the maturation of fruit, and potentially that of pollination vectors) and other threats (Powell and Gould 2017, in prep.; Williams et al. 2006).
- Low fruit set and germination
- Loss of genetic diversity through hybridisation with commercial varieties (O'Connor 2015; NSW NPWS 2002)
- *Phytophthora* root rot (Akinsami 2016)
- Feral pigs (Powell and Gould 2017, in prep.; Ross 2012)

- Pests and diseases from commercial orchards (Powell and Gould 2017, in prep.).

HABITAT ASSESSMENT

Expert(s): Dr Bill McDonald, Dr Catherine Nock, Ms Denise Bond, Mr Ian McConachie (OAM)

Rule(s) for Assigning Habitat Value:

1. Area of assessment confined to South East Queensland Bioregion.
2. Area of assessment further restricted to south of Mt Cotton.
3. Utilisation of regional ecosystems (RE) by the taxon was derived through a spatial intersect of available high precision (post-1974 with a location precision of ≤500m) records with RE mapping produced by the Queensland Herbarium (v10.0). Selected REs were further analysed with regard to frequency and area of buffered point (500m) to determine the significance of individual REs to the species. The consequent complete list of REs identified as preferred habitat for Rough-shelled Bush Nut is included in Appendix 1.
4. Area of assessment was refined to RE polygons containing REs listed in Appendix 1 (in any proportion) and with any part occurring ≤600m above sea level and ≥1000m rainfall.
5. Area of assessment was further restricted to only the portions of RE polygons identified in Rule 4, located within the subcatchment of a high precision record.
6. Within the assessment area, any RE polygons intersected by a buffered high precision record (with a buffer radius 500m irrespective of precision value) were classed as **Preferred Habitat-Known (PHK)**.
7. **Preferred Habitat – Possible (PHP)** was identified as all other polygons containing the REs listed in Rule 2 within the area of assessment.
8. **General Habitat-Known (GHK)** and **General Habitat-Possible (GHP)** were determined to be not relevant to the species.

Rule(s) for Assigning Confidence Level:

1. RE polygons selected as **PHK** are assigned a High confidence. Reason: Known use by the taxon.
2. RE polygons selected as **PHP** are assigned a Medium confidence where these are located >500m and ≤3000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Possible use by the taxon.
3. RE polygons selected as **PHP** are assigned a Low confidence where these are located >3000m of a high precision record (with a buffer radius 500m irrespective of precision value). Reason: Little likelihood of use by the taxon.

A summary of the rules above is provided in Appendix 2.

Overall Confidence:

Species Distribution – High, but will improve with further investigation.

Species Habitat Value Interpretation – Medium, but will improve with further investigation.

Core Habitat:

For the purposes of any Biodiversity Planning Assessment using the Biodiversity Assessment and Mapping Methodology, the experts recommend that Preferred Habitat - Known (High confidence) and Preferred Habitat - Possible (High confidence) be considered Core Habitat. All planning units identified as such should be attributed with the presence of this taxon.

Other Significant Habitat:

In addition to Core Habitat, the expert panel recommends that Preferred Habitat - Possible (Medium confidence) are areas requiring further investigation to which the precautionary principle should be applied.

A Note on Non-Remnant Habitat:

The expert panel considers that non-remnant vegetation surrounding Preferred Habitat of Rough-shelled Bush Nut may be significant for the species and recommends these areas require further investigation to which the precautionary principle should be applied. Further, *M. tetraphylla* trees planted prior to 1940 within cleared landscapes are likely to have been sourced from wild populations and require further investigation; the precautionary principle should be applied to decisions concerning their management.

DATA SUPPORT

Regional Ecosystems: Queensland Herbarium (2017). Regional Ecosystem – Version 10. Department of Natural Resource Management, Brisbane

Landcover: Queensland Department of Natural Resources (2006). Land Cover Change in Queensland 1991-2005, A Statewide Landcover and Trees Study (SLATS) report.

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Appendix 1: List of regional ecosystems in Preferred category for *Macadamia tetraphylla* distribution in the SEQ Bioregion (descriptions from REDD v10.1 March 2018).

- 12.3.1a Complex notophyll vine forest. Typical canopy species include *Castanospermum australe, Elaeocarpus grandis, Grevillea robusta, Cryptocarya obovata, Beilschmiedia obtusifolia, Dysoxylum mollissimum* subsp. *molle, Pseudoweinmannia lachnocarpa, Argyrodendron trifoliolatum, Planchonella australis, Ficus watkinsiana, F. macrophylla* forma *macrophylla, Aphananthe philippinensis, Toona ciliata* and *Syzygium francisii*. Emergent *Eucalyptus grandis* or *Lophostemon confertus* may occur. *Waterhousea floribunda* and *Tristaniopsis laurina* may occur on banks of stream channels. Typical sub canopy species include *Cryptocarya triplinervis, Archontophoenix cunninghamiana, Endiandra pubens, Arytera divaricata, Syzygium moorei* and *Macadamia* spp. Occurs on Quaternary alluvial plains and channels in areas of high rainfall (generally >1300mm). Riverine wetland or fringing riverine wetland.

- 12.3.2 *Eucalyptus grandis +/- E. microcorys, Lophostemon confertus* tall open forest with vine forest understorey ('wet sclerophyll'). Patches of *Eucalyptus pilularis* sometimes present especially in vicinity of sedimentary rocks (e.g. around Palmwoods). Fringing streams and in narrow gullies in high rainfall areas

- 12.3.11 *Eucalyptus tereticornis +/- E. siderophloia* and *Corymbia intermedia* open forest to woodland. *Corymbia tessellaris, Lophostemon suaveolens* and *Melaleuca quinquenervia* frequently occur and often form a low tree layer. Other species present in scattered patches or low densities include *Angophora leiocarpa, E. exserta, E. grandis, C. trachyphloia, C. citriodora subsp. variegata, E. latisinensis, E. tindaliae, E. racemosa and Melaleuca sieberi. E. seeana* may be present south of Landsborough and Livistona decora may occur in scattered patches or low densities in the Glenbar SF and Wongi SF areas. Occurs on Quaternary alluvial plains and drainage lines along coastal lowlands. Rainfall usually exceeds 1000mm/y.

- 12.8.3 Complex notophyll vine forest. Characteristic species include *Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Olea paniculata, Castanospermum australe, Cryptocarya obovata*, *Ficus macrophylla forma macrophylla, Syzygium francisii, Diploglottis australis, Pseudoweinmannia lachnocarpa, Podocarpus elatus, Beilschmiedia obtusifolia, Neolitsea dealbata and Archontophoenix cunninghamiana*. Occurs on Cainozoic igneous rocks, especially basalt <600m altitude

- 12.8.9 *Lophostemon confertus open forest often with vine forest understorey ('wet sclerophyll'). Occurs on Cainozoic igneous rocks. Tends to occur mostly in gullies and on exposed ridges on basalt*.

- 12.11.1 Evergreen notophyll vine forest and/or *Lophostemon confertus* closed forest. *Archontophoenix cunninghamiana* often present in gully floors. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are characteristic of the type. Occurs in gullies on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics

- 12.11.2 Tall open forest with vine forest understorey ('wet sclerophyll'). Canopy species include *Eucalyptus saligna* subsp. *saligna* or *E. grandis, E. microcorys, Corymbia intermedia* and *Lophostemon confertus*. Characteristic understorey species include *Caldcluvia paniculosa, Pittosporum undulatum, Synoum glandulosum* subsp. *glandulosum* and *Cryptocarya microneura*. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics.

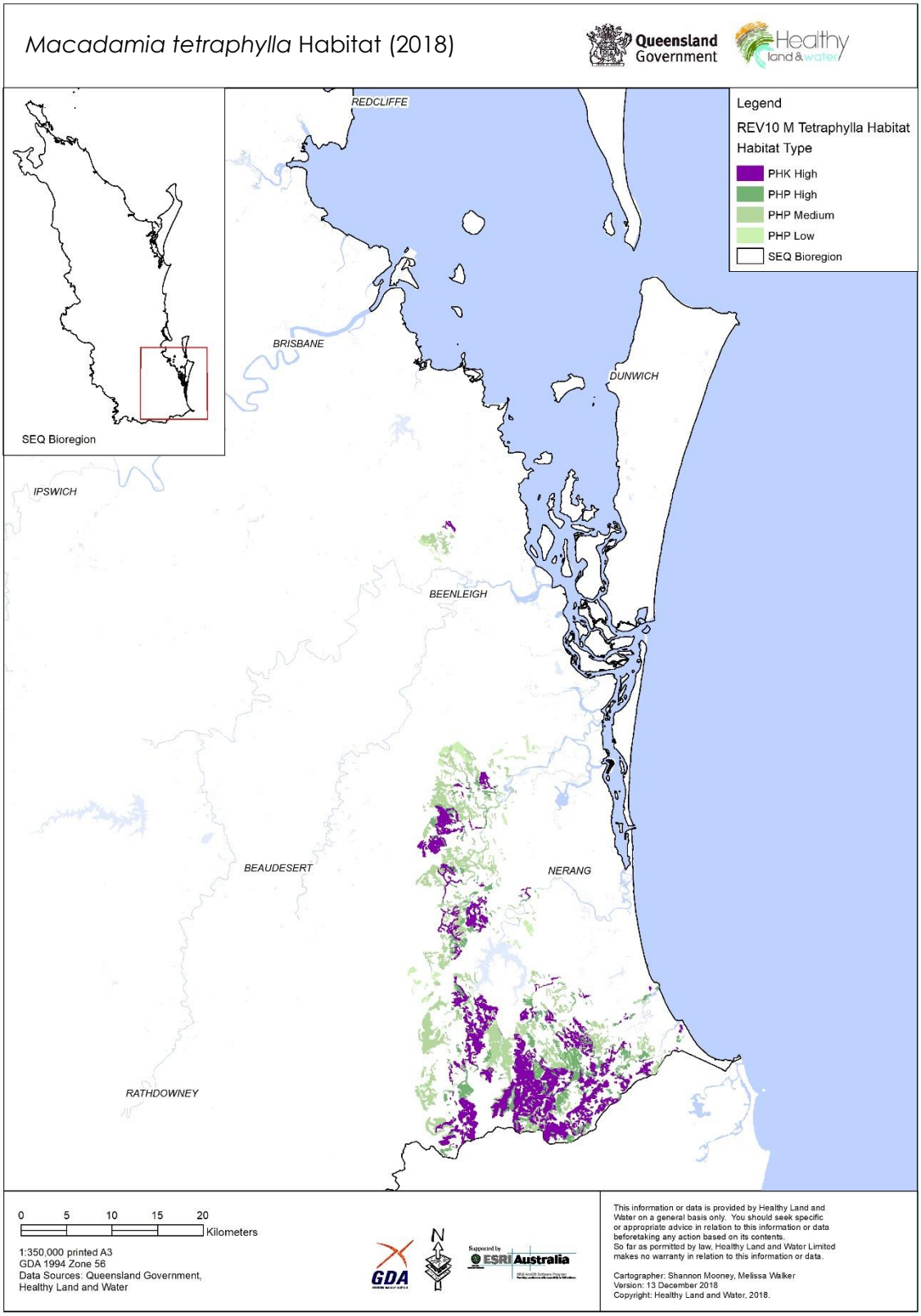
- 12.11.3 *Eucalyptus siderophloia* and *E. propinqua* open forest +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. biturbinata, E. acmenoides, E. tereticornis, E. moluccana, Angophora leiocarpa, Syncarpia verecunda* with vine forest species and *E. grandis or E. saligna* in gullies. *Eucalyptus pilularis* and *E. tindaliae* sometimes present e.g. mid D'Aguilar Range, Conondale Range. Occurs predominantly on hills and ranges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics
- 12.11.3a *Lophostemon confertus +/- Eucalyptus microcorys, E. carnea, E. propinqua, E. major, E. siderophloia woodland*. Occurs in gullies and exposed ridges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics
- 12.11.10 Notophyll and notophyll/microphyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Argyrodendron trifoliolatum, Argyrodendron* sp. (Kin Kin W.D.Francis AQ81198), *Backhousia subargentea, Dissiliaria baloghioides, Brachychiton discolor, Beilschmiedia obtusifolia, Diospyros pentamera, Grevillea robusta, Gmelina leichhardtii* and *Ficus macrophylla forma macrophylla*. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics

Appendix 2: Cross-check of Habitat Value and Confidence Rule-sets for *Macadamia tetraphylla* (categories designated as Core Habitat are shaded).

Habitat Value	**High**	**Medium**	**Low**
PHK	Regional ecosystems identified in Rule 3; AND Within subcatchments south of and including Mt Cotton; Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND ≤500m of a high precision record		
PHP	Regional ecosystems identified in Rule 3; AND Within subcatchments south of and including Mt Cotton; Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >500m and ≤1000m from a high precision record	Regional ecosystems identified in Rule 3; AND Within subcatchments south of and including Mt Cotton; Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >1000m and ≤3000m from a high precision record	Regional ecosystems identified in Rule 3; AND Within subcatchments south of and including Mt Cotton; Altitude ≤600m; AND Rainfall ≥1000mm; AND Intersect or within subcatchment of a high precision record; AND >3000m from a high precision record

GHK			

Appendix 3: Preferred and General Habitat Map for *Macadamia tetraphylla* in the SEQ Bioregion



Macadamia ternifolia.
Photo courtesy of Ian McConachie.

MISSION MACADAMIA

Are you able to distinguish a threatened Macadamia tree from a cultivar?

Liz Gould, Science & Innovation Coordinator – Biodiversity at Healthy Land and Water (HLW).

Arborists can play an important role in the government-endorsed Macadamia Recovery Plan by reporting locations of wild Macadamia trees.

Australia is the only country where Macadamias grow naturally in the wild. They can be found in rainforests remaining along the east coast of Australia, from Bauple in south east Queensland, to Lismore in northern New South Wales, with an isolated population found in central Queensland.

Approximately 80 per cent of Macadamia habitat has been lost due to clearing to make way for a growing urban footprint, agriculture and associated infrastructure. All four Macadamia species are now under threat of extinction in the wild. However, rare discoveries of the original species are being reported in suburban bushland and even older residential areas.

Liz Gould is Science & Innovation Coordinator – Biodiversity at Healthy Land and Water (HLW). In partnership with the Macadamia Conservation Trust, HLW provides education and awareness to the general public, landholders, local governments and the macadamia industry and also fundraises for surveys, research into genetics and onground protection. Funding support is provided by Hort Innovation, the macadamia industry and Redland, Brisbane and Scenic Rim councils through their environmental grants programs.

One of Liz's most exciting finds was a large number of wild Macadamia trees and individual trees at a site in Logan (SEQ). She said arborists are in an ideal position to assist in the search for original macadamias.

"Identification of the big, old trees is important as they could contain genetics of long lost wild populations. During the 1800s and early 1900s, prior to the import of cultivars from Hawaii, tens of thousands of nuts were collected from wild populations and planted in backyards and orchards across Australia. Some of these wild populations no longer exist," she said.

Macadamias grow in a wide range of rainforest types; ranging from rich complex rainforests growing on fertile volcanic soil or alluvium to simple dry rainforest types growing on rocky scree slopes. They were a treasured food for aboriginal people and trees that grew at the fringes of the rainforest were regularly harvested. Much of this rainforest has been cleared since European settlement and what is left is highly fragmented. For reasons unknown, Macadamias tend to occur in population clusters with other areas of apparently suitable habitat unoccupied. It is thought to be related to its lack of ability to disperse long distances. A bushfire or disease could result in a total population being lost.

Large wild tree.
Photo courtesy of Liz Gould.

Multi-stemmed wild tree.
Photo courtesy of Liz Gould.

"Macadamias are part of our heritage and a food that has long been treasured and traded by Australia's traditional owners."

Macadamia habitat.
Photo courtesy of Liz Gould.

Liz said conserving wild Macadamia trees is important to support the macadamia industry, providing access to new genetic material to assist long-term productivity.

"Genetic diversity is vitally important in helping Macadamia species adapt to changing conditions and new diseases," she said.

"Macadamia cultivars contain only a tiny proportion of the genetic diversity present in the wild trees, which evolved over millions of years. Several community groups and indigenous plant nurseries propagate Macadamia but generally in small numbers and usually by seed/nut. Recent research, however, has shown that pollen transfer between cultivated trees and wild trees is occurring. This is reducing the genetic diversity within the resultant seeds, as cultivated trees originated from only a handful of Macadamia trees exported to Hawaii in the early 1900s." ▶

Macadamia industry in a nutshell

The earliest attempts to farm Macadamias in Australia date from the 1870s at Rous Mill near Lismore. However the fledgling Australian industry failed to develop through lack of knowledge, native insect pests and fire.

The Hawaiians commercialised the industry in the 1920s from wild Macadamia tree seeds sourced from south east Queensland rainforests. Hawaiian varieties became the cultivars of the Australian and global industries, leading the world industry until the 1980s.

Australia has since taken its place as the world's largest producer of Macadamia nuts. The local industry currently employs about 5,000 people, produces 40,000 tonnes of nuts and directly contributes millions of dollars to the Australian economy.

The Australian Macadamia industry assists the Macadamia Recovery Plan with funding through annual contributions from processing companies and growers and by including conservation in the constitution of the industry's representative body, the Australian Macadamia Society.

Macadamias are part of our heritage and a food that has long been treasured and traded by Australia's traditional owners. The loss of most of Macadamias' rainforest habitats has also put at risk the many other native plant and animal species that share these habitats including Coxen's Fig-parrot, Spotted-tailed Quoll, Giant Barred Frog, Richmond Birdwing Butterfly and a multitude of plant species.

Sadly, 80 percent of wild macadamia trees have been lost since European settlement, but a lot is now being done to secure their future. Liz Gould believes implementing the recovery plan will take many more years.

"There has been good success over the last seven years, especially with awareness and database establishment. However, resources have limited success in other areas, for example research into key threats and long-term conservation."


Coxen's Fig-parrot.

"Sadly, 80 percent of wild macadamia trees have been lost since European settlement, but a lot is now being done to secure their future."


***Macadamia integrifolia*.**
Photo courtesy of Liz Gould.

Bulberin Nut (*Macadamia jansenii*) is the most threatened of the four macadamia species – known from a one small population in central Queensland; the Trust has worked closely with the University of the Sunshine Coast, the Gidarjil people and Tondoon Botanic Gardens to create ex-situ and in-situ replica populations to try to safeguard against loss of the wild population. Photo courtesy of Liz Gould.

How to identify the four macadamia species.
Look closely at leaf and nut morphology, e.g. three or four leaves to a node, entire or toothed leaves, pointed or rounded ends, pink or green new flush, bumpy or smooth shelled nuts.

- ***Macadamia integrifolia*** (Smooth-shelled Macadamia, Queensland Nut or Bauple Nut) – three leaves to each node, leaves are not as serrated as tetraphylla; new flush is green; flowers are cream; nut shells are smooth
- ***Macadamia tetraphylla*** (Bush Nut or Rough-shelled Macadamia) – four leaves to each node, leaves are spiny with a pointed tip, the new leaf flush is red/brown; flowers generally pinkish-purple; nuts are rough-shelled
- ***Macadamia ternifolia*** (Maroochy or Gympie Nut) – three leaves to each node, leaves have spiny margins and a pointed tip; flowers and new flush are pink; nuts are small and smooth shelled
- ***Macadamia jansenii*** (Bulberin Nut) – three leaves with smooth margins to each node; flowers are cream; new flush is green or pink; nuts are small and smooth shelled. AA


***Macadamia tetraphylla*.**
Photo courtesy of Ian McConachie.

If you are interested in learning more or making a contribution to the Macadamia Conservation Trust please visit www.wildmacadamias.org.au or contact Liz Gould on 0400 748 157 or email wild@macadamias.org.

For more information about the Macadamia industry visit the Australian Macadamia Society website at www.australian-macadamias.org/consumer/


From left, Liz Gould with Martin Bennett, Land for Wildlife Officer, Lockyer Valley Regional Council.

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From: Calyx Horticultural Services <gardening@calyx.com.au>
Sent: Friday, 19 October 2018 10:27 AM
To: gardening@calyx.com.au
Subject: Get Results Gardening - 19 Oct

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Get Results Gardening

SEQld Edition 19 October 2018

TO PLANT OR NOT TO PLANT?

Yucca elephantipes

This species of yucca has been very popular over the last 20 years for its architectural and tropical appearance, tolerance of dry, sunny conditions and lack of sharp spines.

However, specimens planted early on are now maturing and are becoming a problem for many property owners.

The relatively slender young plants might seem OK to plant near walls and fences or in narrow beds, but will proceed to develop multiple trunks and a broad, woody base.

The species name *elephantipes* literally means "elephant foot".

This swollen base could cause damage if located close to structures and will be a chore to physically remove. They re-shoot prolifically if simply cut off near the ground.

Mature flowering specimen with another in the foreground that was cut back and is now resprouting ☞

On the plus side, *Yucca elephantipes* can provide greenery and a tropical touch in tough conditions. They're sure to remain useful where equivalent plants would struggle, provided there's adequate space.

Alternatively, confine them to pots and start over every few years from cut pieces.

A little care is needed when working around them. Eye injuries are always something to be worried about with spiky plants, but it seems these yuccas have a way of **getting into ear canals** as well.

LOCAL NEWS

Join the Wild Macadamia Hunt

Australia's most commercially successful "bushfood" so far is the macadamia.

They're grown on a mass scale around the world, but those plants are the result of a century and a half of breeding and selection. Meanwhile, the progenitors of these plants and their relatives are rare and threatened in the wild.

One of the initiatives to save the survivors and the genetic diversity they contain is The Wild Macadamia Hunt.

It's one you can get involved in, too.

Macadamia species are native to rainforests of SE Qld or Northern NSW and many private properties could contain remnant wild trees or their direct descendants. Extensive planting of macadamias also means that many trees are found outside of rainforest.

If you live in the macadamia's natural range and know of an old specimen (~100 years or more), you can register the tree and send in some photos.

If the submission warrants further investigation, you'll be sent a special kit which will enable you to collect a leaf sample (with permission!) for genetic analysis.

Instructions and more information, including identification guides to target species, can be accessed via the website: **The Wild Macadamia Hunt**

You can also join the **Wild Macadamia Hunters Facebook group** to share the story of your tree and learn more about macadamias.

*Thanks to **Healthy Land & Water** for contributing information and images for this story. The Wild Macadamia Hunt is an initiative of Healthy Land & Water with support from the Brisbane City Council and the Macadamia Conservation Trust.*

BASICS

P is for Phosphorus

Part 2 - Toxicity

Last time we looked at phosphorus deficiency. The other side of the supply coin is toxicity caused by too much.

This isn't a great worry in the course of routine gardening. In the soil, added P tends to be immobilised and converted into unavailable forms at quite a high rate. Most retail fertilisers used according to directions pose little risk of toxicity.

However, there are a couple of scenarios in which P toxicity could occur.

One comes from the common beliefs that phosphorus is specifically needed for root growth or to boost flower production. This could lead gardeners to overdose plants on on high-P fertilisers such as superphosphate.

There is some justification for being extra-attentive to the supply during plant establishment. However, P has not been proven to promote flowering beyond correcting an underlying deficiency. Adding more than needed in either case is wasteful and possibly damaging.

Toxicity might also be encountered when growing certain P-sensitive plants. Nutrient levels in general-purpose fertilisers or soil mixes could be sufficient to create problems with such species.

Of these, the most likely to be grown in local gardens belong to the Proteaceae family, which includes the native *Banksia* and *Grevillea* genera. Not all species are equally sensitive (more on this another time), but it's wise to be cautious with members of this family or other natives adapted to nutrient-poor habitats, including species from Western Australia.

Because P interacts with other minerals in the soil and in the plant, symptoms of toxicity tend appear as other nutrient problems.

Iron deficiency is often the outcome, because P binds with it to form an insoluble compound. Zinc, manganese or copper deficiency or molybdemum excess is also possible.

Banksia *with iron deficiency symptoms*
Derived from **Frank Vincentz**, license **CC BY-SA 3.0**

As an emergency measure, application (especially foliar application) of iron chelate or trace element mix might help until excess P is immobilised or flushed away, at least in mildly affected plants.

If soils are known to have been heavily fertilised in the past, avoid planting sensitive species. If bringing in soil for a new native garden, you can ask you landscape supplier for a low-phosphorus mix to be on the safe side.

THIS WEEKEND

Wriggler Hunting

After so much rain, mosquitoes could be breeding at your place now.

So, check around the house and garden for trapped water.

Pot saucers, bird baths, watering cans, buckets and other containers, sagging gutters, folds in tarpaulins, forgotten toys or even hollow stumps could be harbouring wrigglers.