

Date : 8/08/2019 6:17:16 PM

From : "GEORGE Catherine"

To : "DOWNES Mandy (DES)"

Cc : "CLOUSTON Beth" , "PERSHOUSE Audrey" , "DERWIN Michael"

Subject : FW: Notes for Mandy for Friday

Attachment : 20190730 Koala Protection Reforms MBRC response to LGAQ colour.PDF;

s.73 irrelevant information

s.73 irrelevant information

Local Government Consultation -

Moreton Bay.docx;image001.png;image003.jpg;image004.png;

Mandy, attached are the notes for MBRC and SCC (both rounds). These notes include a recommended response to the key items and the original submission is also attached.

Thanks

Catherine

From: CLOUSTON Beth <Beth.Clouston@des.qld.gov.au>

Sent: Thursday, 8 August 2019 3:58 PM

To: GEORGE Catherine

Cc: PERSHOUSE Audrey

Subject: Notes for Mandy for Friday

Hi Catherine

The Scenic Rim Regional Council did not provide any specific feedback so I have not been able to prepare notes for them.

Notes and the original submissions form Moreton Bay and irrelevant inform are attached.

Notes can be found at:

Moreton Bay: <\\lands\data\DES\CSS\CBPO\Koalas\Strategy\Koala Conservation Strategy\Consultation\LGAQ Consultation\August consultation pack\Local Government Consultation - Moreton Bay.docx>

s.73 irrelevant information

Please let me know if you require any further information.

Beth



Dr Beth Clouston

Program Coordinator

Koala Policy and Oversight Team | Conservation Policy and Planning

Environmental Policy and Programs

Department of Environment and Science

P 07 3330 6110

Level 13, 400 George Street, Brisbane Qld 4000

GPO Box 2454, Brisbane Qld 4001

Email: beth.clouston@des.qld.gov.au



I acknowledge Aboriginal and Torres Strait Islander people as the Traditional Owners of this country, and their connection to land, sea and community.
I pay my respect to all Traditional Owners, and to the Elders past, present and emerging.

Enquiries	Robyn Moffat
Phone	(07) 3205 0555
Our Ref	A18852575 (A18592107)
Your Ref	---
Date	30 July 2019

Kristy Gooding
Lead - Natural Assets and Natural Resource
Management
Local Government Association of Queensland
PO Box 2230
FORTITUDE VALLY BC QLD 4001

Dear Kristy,

PROPOSED KOALA PROTECTION MEASURES

Thank you for the opportunity to provide feedback on the proposed koala protection measures for South East Queensland (SEQ). As advised in Council's correspondence dated 26 June 2019, Moreton Bay Regional Council (Council) discussed the information provided by the State Government (refer Appendix 1) on 25 July 2019.

Council acknowledges the Koala Advisory Council's mandate to provide a better balance between development and the protection of koala habitat and acknowledges the substantial work undertaken to date. However, following review of the information provided, Council has serious concerns that the proposed koala protection measures will not result in the long-term viability of koala populations sought by local governments and the community.

As you would be aware, Council places a high importance on koala conservation in the Moreton Bay region and has, for many years, implemented a range of targeted koala conservation activities in liaison with universities, schools, local wildlife groups and residents.

For example, Council has dedicated 110 Ha of habitat at *The Mill at Moreton Bay* in Petrie for the conservation of wildlife. Since the commencement of the sites' development, the number of koalas inhabiting the site has increased from 45 adults to 71 adults, who now have 24 dependant joeys.

The increase in the koala population at the site is attributed to Council's dedication to proactively manage wild and domestic dog activity, treat koalas infected with koala chlamydial disease, enhance local wildlife habitat corridor linkages and implement fauna movement infrastructure (i.e. road retrofits).

Council is disappointed that the State Government did not seek Local Government's input into the proposed koala protection measures, particularly the proposed mapping, earlier in the reform process. Council also has concerns that areas of known koala presence (e.g. within defined koala habitat areas/wildlife corridor links) have not been included in the proposed State Government koala habitat protection measures.

In addition, the State Government has provided limited detail regarding the impact to Council's planning scheme and how local governments will be enabled to identify and protect matters of local significance.

It is considered imperative that the protection of koala habitat under local government planning schemes is maintained, or improved, from the commencement of the State Government koala protection measures. Due to the timeframes associated with planning scheme amendments, Council seeks assurance from the State Government that it will be provided with full details regarding the proposed planning provisions and transitional arrangements, prior to the endorsement and enactment of the proposed koala protection measures.

Appendix 2 outlines Council's feedback on the information provided and Appendix 3 includes two (2) case studies, detailing examples of Council's concerns.

To facilitate resolution of the matters raised, Council is seeking further consultation with the State Government to ensure that their concerns are addressed, prior to the proposed koala protection measures being finalised and endorsed.

For further information and to arrange additional consultation, please do not hesitate to contact Mrs Robyn Moffat on robyn.moffat@moretonbay.qld.gov.au.

Yours sincerely

sch4p4(6) Personal information

Daryl Hitzman
Chief Executive Officer

Persona

Enc Attachment 1: Information provided by the State Government
Attachment 2: Council feedback and rationale
Attachment 3: Case studies

cc Dr Beth Clouston, Director Policy and Legislation, Department of Environment and Science.

Attachment 1: Information provided by the State Government

1.	Department of Environment and Science (DES) 2019 - Spatial modelling and planning for koalas in southern South East Queensland version 2.1 (the Report) - includes details of the new mapping methodology for koala habitat.
2.	Shapefiles (.shp, .shx, .dbf) of the newly defined koala habitat and Koala Priority Areas.
3.	Total area of the Koala Priority Areas in the Moreton Bay Regional Council Local Government Area.
4.	Total area of the Koala Priority Areas in the SEQ.
5.	Total area of newly defined koala habitat located within the Koala Priority Areas.
6.	Total area of newly defined koala habitat located outside the Koala Priority Areas.
7.	Confirmation that koala habitat trees (in patches or individual trees) do not trigger assessment or compensation measures (e.g. offset) unless they are included as (newly defined) koala habitat.

Published on DES
Disclosure Log Act 2009

Attachment 2: Council feedback and rationale

1. Council acknowledges the proposed Koala Priority Area (KPA) for the Moreton Bay region but believes it can be reviewed to include areas with koala habitat and exclude areas with no habitat (e.g. over built infrastructure).

Council supports the extension of koala habitat protection in the north/west portion of the region. However, Council notes that there are areas of known koala habitat and koala presence in the eastern part of the Moreton Bay region which have not been included in the KPA.

The Report (DES 2019)¹ indicates that lower altitude and alluvial soil areas produce the best quality habitat for koalas. The koala habitat suitability analysis further indicates that in the Moreton Bay region, these areas occur in the eastern part of the region.

While it is acknowledged that the eastern part of the region is subject to threats associated with more intensive development, the mapping methodology report outlines that 'areas in the west of SEQ will be affected by threats such as climate change and heat stress'. Given the long-term threats to koala persistence in the western part of SEQ, it is important that koala habitat in the eastern part is also protected and restored.

Accordingly, Council seeks the opportunity to work with the State Government to review habitat corridors and linkages and their inclusion in the KPA between:

- Freshwater National Park, Deception Bay - Silcock St Park, Clontarf - Northlakes Environmental Reserve, North Lakes - Saltwater Creek and Hays Inlet Conservation Park 2, Redcliffe; and
- King Johns Creek, Caboolture - Six Mile Creek, Elimbah.

2. Council acknowledges the methodology used in the revised koala habitat mapping, however has significant concerns regarding the proposed koala habitat that is mapped for protection.

Council seeks the opportunity to refine the mapping, in collaboration with the State Government, to ensure that areas of known koala habitat/koala presence and koala habitat corridor links are included for protection and enhancement, prior to the mapping being finalised and enacted.

Council acknowledges the Koala Advisory Council's mandate to provide a better balance between development and the protection of koala habitat across the SEQ region.

Council notes that there has been an increase in the area of mapped koala habitat, generally in the western part of the Moreton Bay region, outside the defined urban footprint. Council supports the addition of these areas. It has also been identified that areas of known koala habitat/koala presence have been excluded entirely in some of the eastern parts of the Moreton Bay region.

While Council understands that a decision has been made to adopt a mapping methodology which only includes remnant and regrowth koala habitat, Council questions whether the resulting mapping is a true and accurate representation of koala habitat across SEQ.

As outlined in the Report (DES 2019)¹ non-remnant vegetation "often represents the only habitat left where food and shelter trees remain in an otherwise cleared landscape" and concludes that these areas are "critical for koala conservation given the significant loss of core habitat to date".

¹ Department of Environment and Science (DES) 2019. *Spatial modelling and planning for koalas in southern South East Queensland*. Report version 2.1

Despite this association, the proposed mapping methodology excludes non-juvenile koala habitat trees outside of regional ecosystems. This decision has significant implications for koala habitat protection in the Moreton Bay region.

Council also notes that the proposed koala habitat mapping includes mapped areas over built infrastructure. Council recommends that areas of koala habitat mapped over built infrastructure be redefined.

To assist the State Government optimise koala habitat protection across the Moreton Bay region, Council seeks the opportunity to work with the State Government to refine the mapping, prior to it being finalised and enacted.

3. Council recommends the State incorporate habitat corridors/linkages into the mapping and planning provisions

The Koala Expert Panel Report recommended that the Koala Conservation Strategy should identify “a network of connected priority areas for koalas”. While the KPA within the Moreton Bay region is a connected priority area for koalas, it is noted that KPAs across SEQ do not provide landscape connectivity.

Given this, it is unclear how the proposed KPAs and koala habitat mapping will provide for the long-term sustainability of koalas. Council recommends, at a minimum, koala habitat links/corridors should be embedded in the proposed koala protection measures.

To assist the State Government optimise koala habitat protection across the Moreton Bay region, Council seeks the opportunity to work with the State Government to refine the mapping prior to it being finalised and endorsed.

4. Council recommends that the State support local governments to identify and protect local matters (MLES) to enable protection of values, not mapped by the State

Council has concerns that the proposed reforms will restrict the ability of Local Governments to protect matters of local significance, including koala habitat and corridors for locally significant koala populations.

The current koala habitat mapping and protection measures appear to contradict the 2017 Koala Expert Panel recommendation:

2.2(g) Allow locally significant koala habitat, not captured by the Queensland Government mapping or within identified priority areas for koalas, to be able to be protected through local government planning schemes.

Council seeks the opportunity to work with the State Government to ensure that there is a defined and supported process to identify and protect matters of local significance, enabling protection of values not mapped by the State.

5. Council supports, in principle, the proposed State Government assessment manager arrangements

Council supports (in principle) the proposed State Government assessment manager arrangements.

However, Council has not been provided with a copy of the proposed State Development Assessment Provisions (SDAP) and consequently, it is not possible to fully assess the potential impacts of the State Government becoming the assessment manager.

Council seeks the opportunity to work with the State Government to clarify the proposed assessment manager arrangements. Council also seeks assurance from the State Government that the level of assessment currently undertaken by local government is maintained (or improved), including thorough assessment of ecological reports provided by proponents.

6. Council supports, in principle, proposed offset arrangements

Council supports (in principle) the State Government's proposal to become the administering authority for offsets.

However, Council is concerned that the extent of the proposed restoration areas, in combination with the proposed offset restoration location hierarchy, may result in offset activities being located in areas which are not optimal from a local koala conservation perspective.

Council recommends that the offset restoration location hierarchy includes:

- Prioritisation of rehabilitation areas identified by local government as requiring enhancement, particularly where these areas overlap with the proposed KPA restoration areas and
- Guiding principles for locating offset restoration activities 'within the KPA closest to the impact site' in areas which will restore habitat connectivity between areas known to be favourable for koalas (i.e. ground-truthed).

Council seeks the opportunity to work with the State Government to clarify the proposed offsets arrangements.

7. Council seeks a review of the cumulative impact of mapping changes and exemptions

The 2017 Koala Expert Panel report included a recommendation to remove the exemptions or substantially reduce their scope as they apply to koala habitat, as this is vital for effectively protecting koala habitat (recommendation 2.2(b)).

The State Government's response to this recommendation was "The Queensland Government will address development assessment exemptions that have an adverse impact on koala habitat".

Council has concerns that the exemptions have not been adequately addressed and recommends that the State Government review of the cumulative impact of mapping changes and exemptions to ensure that koala conservation outcomes can be achieved.

8. Council recommends that the State Government implement mitigation measures to address displaced koalas

As noted in 1 and 2 above, the proposed amendments to the koala habitat mapping and associated protection measures excludes a significant number of non-juvenile koala habitat trees across the Moreton Bay region. Case studies of the impact of the proposed amendments are included in Attachment 3.

Case study 1 is for the suburb of Joyner. Joyner is located within the proposed KPA and is also within the urban footprint. The Joyner area contains a very high number of non-juvenile koala habitat trees and has known koala presence. The proposed amendments will remove koala habitat protection measures across the Joyner area, except for the riparian zone along One Mile Creek.

Case study 2 is in the suburb of Burpengary (area known as Pine Valley). Pine Valley is located within the proposed KPA and is also within the urban footprint. The Pine Valley area contains a very high number of non-juvenile koala habitat trees and has known koala presence. The proposed amendments significantly reduce koala habitat protection across Pine Valley and does not support the establishment of local wildlife corridor links between established habitat areas.

Based on Council's review of the proposed koala habitat to be protected within the Moreton Bay region, it is anticipated that a significant number of non-juvenile koala habitat trees will be able to be cleared by proponents, without any requirement to avoid or mitigate impacts.

In addition to addressing items 1 and 2 above, Council recommends that the State Government urgently consider mitigation measures to address displaced koalas, and other wildlife including:

- financial and non-financial support for local wildlife carers who will be involved in the rescue and care of displaced wildlife;
- a coordinated SEQ relocation program for displaced koalas; and
- implementation of mandatory sequential clearing provisions and koala spotter requirements for the clearing of any non-juvenile koala habitat tree known to be a food or habitat tree for koalas in SEQ.

9. Council requires the State to take full responsibility for communicating the rationale and scope of the proposed changes to the community

Council expects that the State Government's proposed changes to the koala protection measures will result in a high degree of community concern, due to the loss of protection for non-juvenile koala habitat trees in the Moreton Bay area, known to be a food or habitat trees for koalas. It is also anticipated that the lack of local corridors and linkages between areas of mapped koala habitat will also be of concern.

Council seeks confirmation from the State Government that it will be primary contact point to respond to community concerns relating to the proposed koala reforms, including changes to the koala habitat mapping and impact to local koala populations.

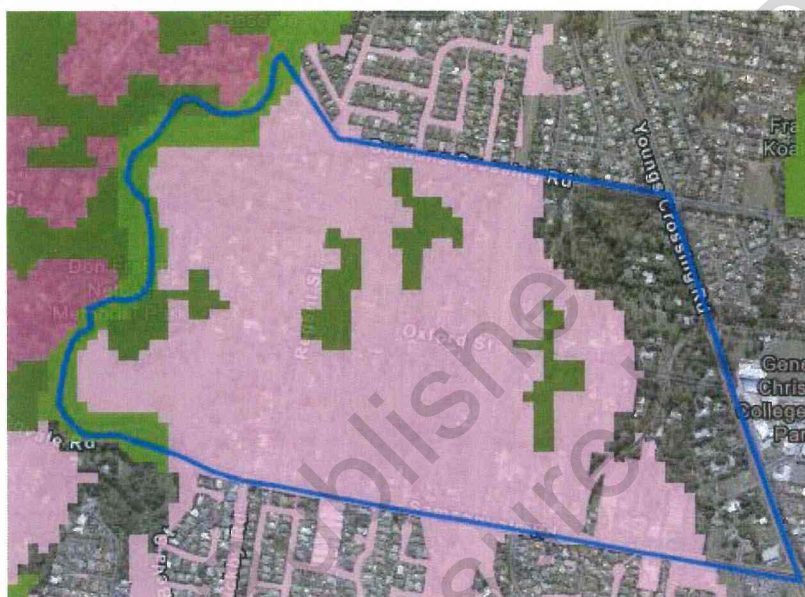
Attachment 3: Case Study Areas

Case Study 1 - Joyner

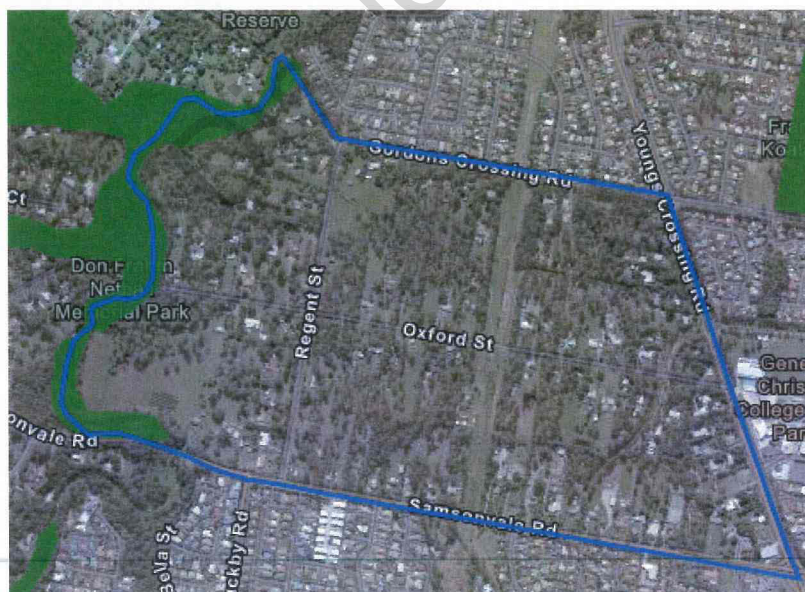
- Rural residential - current zoning Emerging Community.
- Within the current Priority Koala Assessable Development Area.
- Under the proposed new provisions, the area would be included in the Koala Priority Area.
- The proposed changes to the habitat mapping result in a significant reduction in the area where clearing is prohibited, and a further reduction in the area requiring avoidance, mitigation and offsetting.
- The proposed changes will allow for a large number of non-juvenile koala habitat trees to be removed.
- The proposed changes do not support the establishment of local wildlife corridors.
- The State Government has not provided any details regarding mitigation measures to address displaced koalas (and other wildlife) or details regarding support for wildlife carers.

	Existing	Proposed
Mapped habitat - clearing prohibited	17.2 ha	6.1 ha
Mapped habitat - avoid, minimize offset clearing	92.6 ha	0 ha

Existing mapping



Proposed mapping:

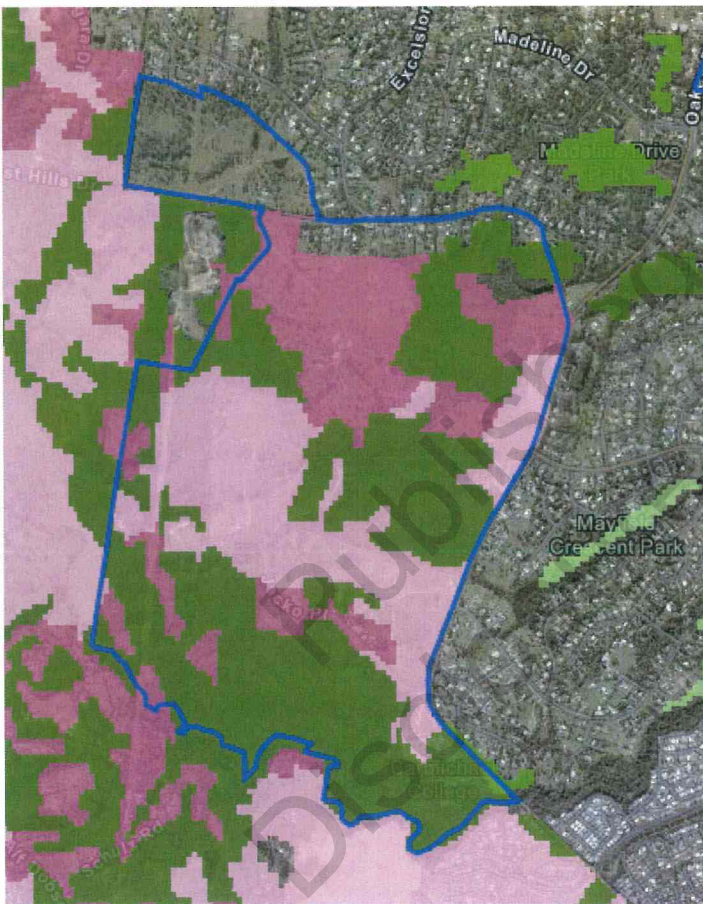


Case Study 2 - Pine Valley

- Current zoning rural
- Within the current Koala Assessable Development Area.
- Under the proposed new provisions, the area would be included in the Koala Priority Area.
- The proposed changes to the habitat mapping result in a significant reduction in the area requiring avoidance, mitigation and offsetting.
- The proposed changes will allow for a large number of non-juvenile koala habitat trees to be removed.
- The proposed changes do not support the establishment of local wildlife corridors.
- The State Government has not provided any details regarding mitigation measures to address displaced koalas (and other wildlife) or details regarding support for wildlife carers.

	Existing	Proposed
Mapped habitat - clearing prohibited	0 ha	59.5 ha
Mapped habitat - avoid, minimise, offset clearing	459.5 ha	0 ha

Existing mapping



Proposed mapping:



Local Government Consultation – August 2019

Specific issues from Moreton Bay Regional Council

General

- Concerned that the koala protection measures will not result in the long-term viability of koalas.
- Council notes it has undertaken koala conservation activities and in particular the 110ha of habitat it has protected at *the mill*. They also note the threat mitigation activities undertaken.
- Council would like to have seen the mapping earlier. Response: mapping has used an ecological methodology and consultation was undertaken with experts in the area of mapping.
- In particular, they are concerned that areas with known koala presence have not been included.
- Require further detail on impacts on planning scheme and how local governments will identify areas of local environmental significance. Response: the transitional areas approach with two years for plan amendment.
- Note that the mapping referred to under the local government planning schemes is mapping developed by the state government in 2009. It is clear that the current approach is not working. So the state is changing from one set of mapped areas to another.

Specific feedback

- Concerned areas in the eastern part of Moreton Bay not included in KPA.
- Note a number of areas of want included. Added in all the areas requested with the exception of Deception Bay – Silcock St Park, (adjacent to mangrove area and surrounded by suburbs and Hays Inlet), Hays Inlet Conservation Park 2 (tidal mangrove area) Kings John Creek, Caboolture and Six Mile Creek Elimbah – (areas disconnected from other koala habitat).
- Council wants to refine the mapping to ensure areas of known koala habitat/presence is included prior to map finalisation.
- Council questioning why we haven't included regrowth mapping and scattered non-juvenile koala habitat trees. Response: The decision not to include scattered trees was that this is not the relevant level of regulation for the state government. The government understands the importance of regrowth vegetation for koala but until there is consistent high quality regrowth vegetation available this has not been included.
- Concerned that all KPAs are connected across SEQ. Response: this is because of disconnected habitat and highly urbanised areas.
- Council want koala habitat links/corridors embedded in protection areas.
- Council request that there is a defined and supported process to identify MLES. Response: the transitional areas approach with two years for plan amendment.
- Council support state government assessment role.
- Council requested copy of the SDAP and assurance that the state will undertake a thorough assessment of ecological reports. Response: SDAP has been provided.
- Concerned that offsets may not be located in optimal areas. Request that areas LG identify for rehabilitation are prioritised.

Date : 3/10/2019 4:02:39 PM
From : "GEORGE Catherine"
To : "PERSHOUSE Audrey"
Subject : FW: PRIORITY - Please review and clarify mapping intent
Attachment : image001.png;image003.jpg;
fyi

From: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Sent: Thursday, 3 October 2019 1:44 PM
To: Robyn Moffat
Cc: Crystal Baker; Kristy Gooding; Ben McMullen; Vanessa Keogh; Nikita Tully; GEORGE Catherine; HOPPER Karen; WOOLSEY David
Subject: RE: PRIORITY - Please review and clarify mapping intent

Hi Robyn

Thanks again for raising this inconsistency with me.

You are correct to say that based on the mapping information the layers protected include GHD bushland (High, Medium and Low) and rehabilitation (High and Medium). These layers are consistent with other local governments that have provided mapping information. This is also consistent with the technical report that supports the mapping across South East Queensland. I am investigating the source of the misinformation to ensure that this confusion doesn't repeat.

As per our discussion yesterday, and your imagery, I note that there are significant areas where development has been approved in rehabilitation areas. The department is working through a process to clip back rehabilitation areas removing developed areas ensure a higher level of accuracy for these maps. As such, the areas mapped as Locally Refined Koala Habitat Areas will have some refinement. I will be able to provide you with an indicative timeframe for this work in the next couple of days.

I trust this will provide you with the relevant information required to brief the Mayor and Councillors.

I do apologise for the confusion in the advice provided earlier this week.

Regards

Mandy



Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
Department of Environment and Science
P 07 3330 5818 : M
Level 13, 400 George Street, Brisbane
GPO Box 2454, Brisbane 4001

From: Robyn Moffat <Robyn.Moffat@moretonbay.qld.gov.au>
Sent: Wednesday, 2 October 2019 4:23 PM
To: DOWNES Mandy (DES); GEORGE Catherine; HOPPER Karen; WOOLSEY David
Cc: Crystal Baker; Kristy Gooding; Ben McMullen; Vanessa Keogh; Nikita Tully
Subject: PRIORITY - Please review and clarify mapping intent
Importance: High

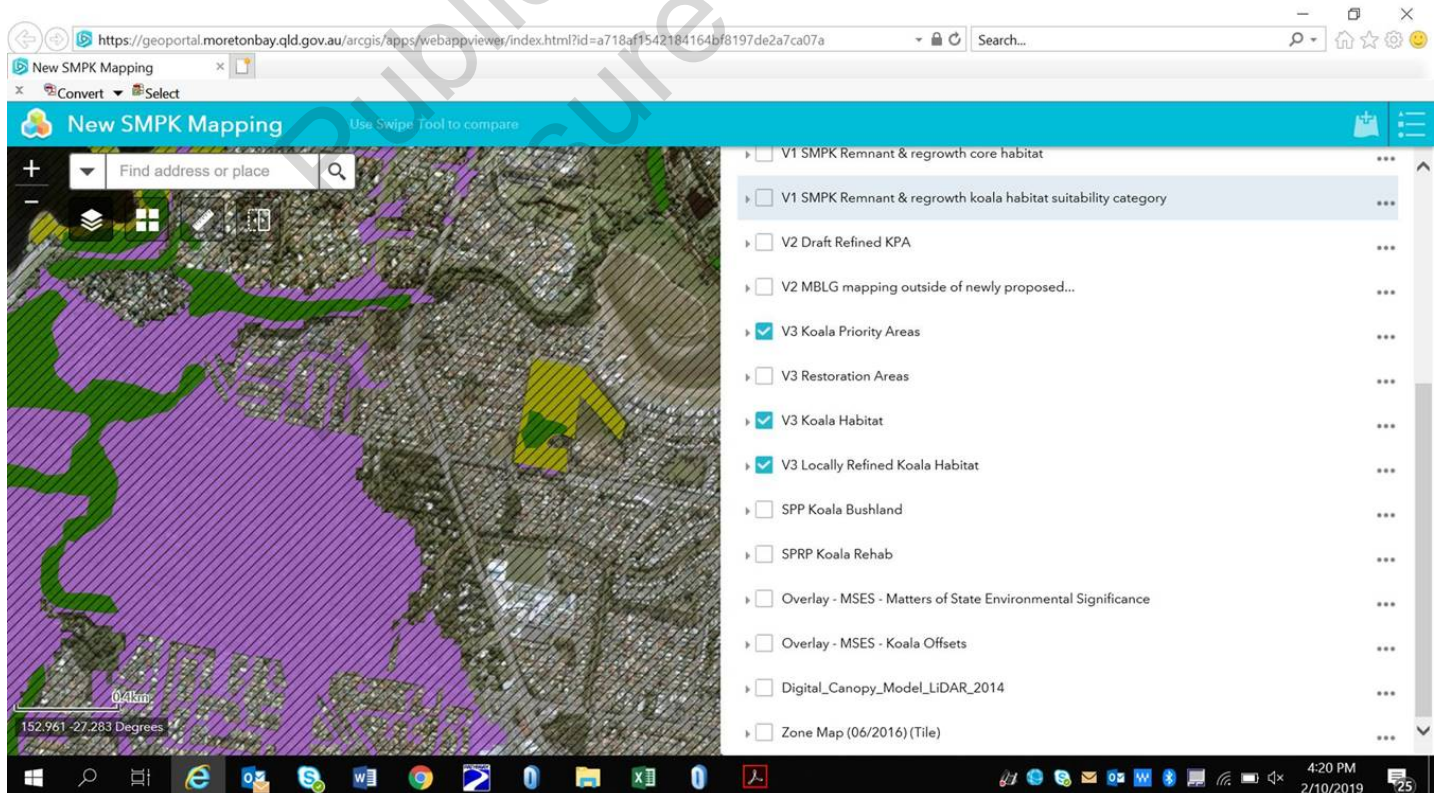
Hi Everyone,

Thank you for providing the spatial files as requested. As discussed with Mandy - see below extract - can you please urgently review the mapping and please provide clarification.

The mapping appears to include GHD Bushland (High, Medium and Low) in addition to Rehabilitation Habitat (High and Medium) within the existing PKADA and KADA areas. This reflects the mapping in the current planning scheme and is likely to reflect the community's expectations. However, this is not aligned with your previous verbal and written advice as per below.

If the Rehabilitation Habitat (High and Medium) is to be included, can you also confirm whether the prohibition will apply to these areas.

Thanks and give me a call, if required.



Regards

Robyn Moffat
Manager, Environmental Services

From: GEORGE Catherine <Catherine.George@des.qld.gov.au>

Sent: Tuesday, 1 October 2019 4:09 PM

To: Robyn Moffat <Robyn.Moffat@moretonbay.qld.gov.au>

Cc: Kristy Gooding <Kristy.gooding@lga.qld.gov.au>; 'Crystal Baker' <Crystal_Baker@lga.qld.gov.au>; Environmental Services Mailbox <esmailbox@moretonbay.qld.gov.au>; HOPPER Karen <Karen.Hopper@des.qld.gov.au>;

DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>

Subject: RE: Request for clarification - Letter from Director General to MBRC

Good afternoon,

Further to the below email, I am providing a version of all mapping products in a GIS format for your area.

Please find attached a zipped folder containing the latest version of:

1. Koala Priority Areas (KPAs)
2. Koala Habitat Areas
3. Koala Habitat Restoration Area Map (KHRAM)
4. Locally refined koala habitat map

These files have been provided in geodatabase format. A technical report is also attached to this email to detail the methodologies used to develop the mapping products.

A reminder that these mapping products are confidential and not for distribution. The use of these products is bound to the confidentiality agreement executed during the State koala habitat reform consultation.

If there are any issues with the mapping products provided please contact David Woolsey by email at david.woolsey@des.qld.gov.au.

Regards

Catherine

From: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>

Sent: Tuesday, 1 October 2019 1:40 PM

To: Robyn Moffat

Cc: Kristy Gooding; 'Crystal Baker'; Environmental Services Mailbox; GEORGE Catherine; HOPPER Karen

Subject: RE: Request for clarification - Letter from Director General to MBRC

Hi Robyn,

Thanks for your time to talk through this today. As discussed, below is the written advice in response to each of your questions.

1. The extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)]

All types of bushland habitat (high, medium and low) has been included.

2. Where will the above determined/defined mapping be applied?

- o 2.1 Across the whole MBRC region or
- o 2.2 Within the defined Koala Priority Area only

Mapping is applied across the whole MBRC area. As discussed, the mapping will follow.

3. What planning provisions/regulation apply to the mapped areas, within and outside the Koala Priority Area (including the transitional areas). I have attached the previously provided draft trigger tables and your advice regarding the application of these is appreciated.

For consistency, the same provisions that apply to state mapping (i.e. prohibition in a KPA and avoid/mitigate/offset outside a KPA) will apply.

4. Where is the defined (final version) Koala Priority Area boundary for the Moreton Bay region?

Could you also provide, at your earliest convenience, shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping that will be applied across the Moreton Bay region and Koala Priority Area boundary so that we can load it into our GIS system for review (spatially).

Shape files will follow this email.

5. Areas within the Moreton Bay region (growth areas/targets) that DES are aware of that will be impacted/influenced by the proposed mapping

As discussed, this analysis is being undertaken by DSDMIP and we are awaiting the results.

6. The intent of the proposed planning provisions and exemptions regarding mapped koala habitat, specifically -

- o 6.1 Development (within the Koala Priority Area) which purports to 'not require clearing of koala habitat', but approval of the development could result in subsequent clearing of koala habitat which is 'exempted development', will the (parent) development prohibited development?

The prohibition applies to subdivisions (reconfiguring a lot) where, in creating new lots, koala habitat will need to be cleared.

Existing lots can utilise the exemptions, for example, to maintain their fence lines or create new ones that are considered necessary (e.g. a required pool fence).

The exemptions do not restrict the local government's plan making options should the vegetation meet a different MSES, or a local categorising instrument's MLES, nor do they prevent the application of a covenant or other vegetation protection mechanism should the assessment manager decide that it is reasonable and relevant for the development.

7. What the proposed provisions/regulations would be in the following circumstance -

A proponent has submitted an application to DNRM and have had their property assessed against the Vegetation Management Act 1999. The proponent has subsequently been provided with a PMAV that redefines the their lot as "Category X" under the Vegetation Management Act 1999. The lot also contains mapped koala habitat (MSES - GHD mapping - as per the Moreton Bay Regional Council Planning Scheme).

7.1 What are the koala habitat protection arrangements in this instance?

Clearing exemption for category x areas will only be allowed if the koala habitat is both core koala habitat area and category x as per the VMA.

7.2 Will the clearing of the koala habitat be prohibited?

To the extent that the category x area is a koala habitat area which is not core koala habitat, the clearing will be prohibited.

As requested, we will investigate the Pine Valley emerging community area and provide separate advice.

Thanks again for your time and please let me know if there is anything further you will require.

Regards

Mandy



Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
Department of Environment and Science

P 07 3330 5818 : M **Personal**
Level 13, 400 George Street, Brisbane
GPO Box 2454, Brisbane 4001

From: Robyn Moffat <Robyn.Moffat@moretonbay.qld.gov.au>
Sent: Monday, 30 September 2019 12:34 PM
To: DOWNES Mandy (DES); HOPPER Karen
Cc: Kristy Gooding; 'Crystal Baker'; Environmental Services Mailbox; GEORGE Catherine
Subject: RE: Request for clarification - Letter from Director General to MBRC
Importance: High

Hi Mandy and Karen,

Thank you Karen for your voice message last week confirming that a response was being prepared regarding Council's request for further information. Could you please provide an update at your earliest convenience.

In particular, Council's Director Planning & Economic Development, Mike Pickering is urgently waiting advice regarding the extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)] and the shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping and Koala Priority Area boundary that will be applied across the Moreton Bay region.

Thanks in advance and please do not hesitate to contact me if required.

Regards

Robyn Moffat
Manager, Environmental Services
Environmental Services Department
Moreton Bay Regional Council
PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: **Personal**
E: robyn.moffat@moretonbay.qld.gov.au

From: Robyn Moffat
Sent: Tuesday, 24 September 2019 4:16 PM
To: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Cc: Kristy Gooding <Kristy_Gooding@lga.qld.gov.au>; Crystal Baker <Crystal_Baker@lga.qld.gov.au>
Subject: Request for clarification - Letter from Director General to MBRC

Hi Mandy,

In reference to the attached letter received by Council's Acting Chief Executive Officer, Graeme Kanofski could you please provide clarification on the below points. This will enable the team to update Directors and Councillors.

With reference to advice from the Director General that - "I have decided to include all existing koala habitat under the existing GHD mapping in order to ensure that more, rather than less, potential habitat is protected" could you please clarify:

1. The extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)]
2. Where will the above determined/defined mapping be applied?
 - o 2.1 Across the whole MBRC region or
 - o 2.2 Within the defined Koala Priority Area only
3. What planning provisions/regulation apply to the mapped areas, within and outside the Koala Priority Area (including the transitional areas). I have attached the previously provided draft trigger tables and your advice regarding the application of these is appreciated.
4. Where is the defined (final version) Koala Priority Area boundary for the Moreton Bay region?

Could you also provide, at your earliest convenience, shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping that will be applied across the Moreton Bay region and Koala Priority Area boundary so that we can load it into our GIS system for review (spatially).

With reference to the comment from the Director General that - "inclusion of these (mapped) areas may impact on achieving Shaping SEQ dwelling targets within MBRC.." could you please clarify:

5. Areas within the Moreton Bay region (growth areas/targets) that DES are aware of that will be impacted/influenced by the proposed mapping
6. The intent of the proposed planning provisions and exemptions regarding mapped koala habitat, specifically -
 - o 6.1 Development (within the Koala Priority Area) which purports to 'not require clearing of koala habitat', but approval of the development could result in subsequent clearing of koala habitat which is 'exempted development', will the (parent) development prohibited development?

Examples for context -

A subdivision proposes a new lot boundary within 4m of koala habitat. The development claims the koala habitat will be retained by the proposal. A future landowner may be able to clear the koala habitat as it accords with the 'exempted development' criteria. Will the original subdivision proposal be considered to be prohibited development?

A lot reconfiguration 'does not require clearing of koala habitat' but results in 500m2 lots which contain koala habitat. The koala habitat could subsequently be cleared as exempt clearing work (clearing of up to 500m2 of koala habitat). Will the lot reconfiguration be considered to be prohibited development?

With reference to the comment from the Director General's that - "Exemptions were also drafted to align (wherever possible) to the corresponding exemptions under the State's Vegetation Management Framework to avoid unnecessary inconsistencies." could you please clarify:

7. What the proposed provisions/regulations would be in the following circumstance -

A proponent has submitted an application to DNRM and have had their property assessed against the *Vegetation Management Act 1999*. The proponent has subsequently been provided with a PMAV that redefines their lot as "Category X" under the *Vegetation Management Act 1999*. The lot also contains mapped koala habitat (MSES - GHD mapping - as per the Moreton Bay Regional Council Planning Scheme).

 - 7.1 What are the koala habitat protection arrangements in this instance?
 - 7.2 Will the clearing of the koala habitat be prohibited?

Thank you for your advice. Please don't hesitate to give me a call should you require any further information or details regarding the above questions. I'll touch base with you later in the week.

Regards

Robyn Moffat

Manager, Environmental Services
Environmental Services Department
Moreton Bay Regional Council
PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: [Personal](#)
E: robyn.moffat@moretonbay.qld.gov.au

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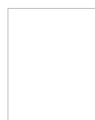
Date : 2/10/2019 6:17:35 PM
From : "GEORGE Catherine"
To : "PERSHOUSE Audrey"
Subject : Fwd: PRIORITY - Please review and clarify mapping intent
Attachment : Moreton Bay LGA.gdb.zip;ATT00001.htm;SMPK Koala Habitat Mapping v1_0.pdf;ATT00002.htm;
For review please;

Sent from my iPhone

Begin forwarded message:

From: "HOPPER Karen" <Karen.Hopper@des.qld.gov.au>
To: "GEORGE Catherine" <Catherine.George@des.qld.gov.au>
Cc: "DOWNES Mandy (DES)" <Mandy.Downes@des.qld.gov.au>
Subject: FW: PRIORITY - Please review and clarify mapping intent

Hi Catherine
Can we pls review this as a priority. Advice back to Mandy prior to contacting Council please
Thanks
Karen



Karen Hopper
Director
Conservation Policy and Planning Branch
Department of Environment and Science
P 07 3330 5174 Mob **Personal**
Level 13, 400 George Street, Brisbane
GPO Box 2454, Brisbane 4001

From: Robyn Moffat [<mailto:Robyn.Moffat@moretonbay.qld.gov.au>]
Sent: Wednesday, 2 October 2019 4:23 PM
To: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>; GEORGE Catherine <Catherine.George@des.qld.gov.au>; HOPPER Karen <Karen.Hopper@des.qld.gov.au>; WOOLSEY David <David.Woolsey@des.qld.gov.au>
Cc: Crystal Baker <Crystal_Baker@lgaq.asn.au>; Kristy Gooding <Kristy_gooding@lgaq.asn.au>; Ben McMullen <Ben.McMullen@moretonbay.qld.gov.au>; Vanessa Keogh <Vanessa.Keogh@moretonbay.qld.gov.au>; Nikita Tully <Nikita.Tully@moretonbay.qld.gov.au>
Subject: PRIORITY - Please review and clarify mapping intent
Importance: High

Hi Everyone,

Thank you for providing the spatial files as requested. As discussed with Mandy - see below extract - can you please urgently review the mapping and please provide clarification.

The mapping appears to include GHD Bushland (High, Medium and Low) in addition to Rehabilitation Habitat (High and Medium) within the existing PKADA and KADA areas. This reflects the mapping in the current planning scheme and is likely to reflect the community's expectations. However, this is not aligned with your previous verbal and written advice as per below.

If the Rehabilitation Habitat (High and Medium) is to be included, can you also confirm whether the prohibition will apply to these areas.

Thanks and give me a call, if required.

Regards

Robyn Moffat
Manager, Environmental Services
Environmental Services Department
Moreton Bay Regional Council
PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: **Personal**
E: robyn.moffat@moretonbay.qld.gov.au

From: GEORGE Catherine <Catherine.George@des.qld.gov.au>
Sent: Tuesday, 1 October 2019 4:09 PM

To: Robyn Moffat <Robyn.Moffat@moretonbay.qld.gov.au>
Cc: Kristy Gooding <Kristy_gooding@lga.qld.gov.au>; 'Crystal Baker' <Crystal_Baker@lga.qld.gov.au>; Environmental Services Mailbox <esmailbox@moretonbay.qld.gov.au>; HOPPER Karen <Karen.Hopper@des.qld.gov.au>; DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Subject: RE: Request for clarification - Letter from Director General to MBRC

Good afternoon,

Further to the below email, I am providing a version of all mapping products in a GIS format for your area.

Please find attached a zipped folder containing the latest version of:

1. Koala Priority Areas (KPAs)
2. Koala Habitat Areas
3. Koala Habitat Restoration Area Map (KHRAM)
4. Locally refined koala habitat map

These files have been provided in geodatabase format. A technical report is also attached to this email to detail the methodologies used to develop the mapping products.

A reminder that these mapping products are confidential and not for distribution. The use of these products is bound to the confidentiality agreement executed during the State koala habitat reform consultation.

If there are any issues with the mapping products provided please contact David Woolsey by email at david.woolsey@des.qld.gov.au.

Regards
Catherine

From: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Sent: Tuesday, 1 October 2019 1:40 PM
To: Robyn Moffat
Cc: Kristy Gooding; 'Crystal Baker'; Environmental Services Mailbox; GEORGE Catherine; HOPPER Karen
Subject: RE: Request for clarification - Letter from Director General to MBRC

Hi Robyn,

Thanks for your time to talk through this today. As discussed, below is the written advice in response to each of your questions.

1. **The extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)]**

All types of bushland habitat (high, medium and low) has been included.

2. **Where will the above determined/defined mapping be applied?**

- 2.1 Across the whole MBRC region or
- 2.2 Within the defined Koala Priority Area only

Mapping is applied across the whole MBRC area. As discussed, the mapping will follow.

3. **What planning provisions/regulation apply to the mapped areas, within and outside the Koala Priority Area (including the transitional areas). I have attached the previously provided draft trigger tables and your advice regarding the application of these is appreciated.**

For consistency, the same provisions that apply to state mapping (i.e. prohibition in a KPA and avoid/mitigate/offset outside a KPA) will apply.

4. **Where is the defined (final version) Koala Priority Area boundary for the Moreton Bay region?**

Could you also provide, at your earliest convenience, shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping that will be applied across the Moreton Bay region and Koala Priority Area boundary so that we can load it into our GIS system for review (spatially).

Shape files will follow this email.

5. **Areas within the Moreton Bay region (growth areas/targets) that DES are aware of that will be impacted/influenced by the proposed mapping**

As discussed, this analysis is being undertaken by DSDMIP and we are awaiting the results.

6. **The intent of the proposed planning provisions and exemptions regarding mapped koala habitat, specifically -**

- 6.1 Development (within the Koala Priority Area) which purports to 'not require clearing of koala habitat', but approval of the development could result in subsequent clearing of koala habitat which is 'exempted development', will the (parent) development prohibited development?

The prohibition applies to subdivisions (reconfiguring a lot) where, in creating new lots, koala habitat will need to be cleared.

Existing lots can utilise the exemptions, for example, to maintain their fence lines or create new ones that are considered necessary (e.g. a required pool fence).

The exemptions do not restrict the local government's plan making options should the vegetation meet a different MSES, or a local categorising instrument's MLES, nor do they prevent the application of a covenant or other vegetation protection mechanism should the assessment manager decide that it is reasonable and relevant for the development.

7. **What the proposed provisions/regulations would be in the following circumstance -**

A proponent has submitted an application to DNRM and have had their property assessed against the Vegetation Management Act 1999. The proponent has subsequently been provided with a PMAV that redefines the their lot as "Category X" under the Vegetation Management Act 1999. The lot also contains mapped koala habitat (MSES - GHD mapping - as per the Moreton Bay Regional Council Planning Scheme).

- 7.1 What are the koala habitat protection arrangements in this instance?

Clearing exemption for category x areas will only be allowed if the koala habitat is both core koala habitat area and category x as per the VMA.

- 7.2 Will the clearing of the koala habitat be prohibited?

To the extent that the category x area is a koala habitat area which is not core koala habitat, the clearing will be prohibited.

As requested, we will investigate the Pine Valley emerging community area and provide separate advice.

Thanks again for your time and please let me know if there is anything further you will require.

Regards

Mandy

Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
Department of Environment and Science

P 07 3330 5818 : M **Personal**
Level 13, 400 George Street, Brisbane

From: Robyn Moffat <Robyn.Moffat@moretonbay.qld.gov.au>
Sent: Monday, 30 September 2019 12:34 PM
To: DOWNES Mandy (DES); HOPPER Karen
Cc: Kristy Gooding; 'Crystal Baker'; Environmental Services Mailbox; GEORGE Catherine
Subject: RE: Request for clarification - Letter from Director General to MBRC
Importance: High

Hi Mandy and Karen,

Thank you Karen for your voice message last week confirming that a response was being prepared regarding Council's request for further information. Could you please provide an update at your earliest convenience.

In particular, Council's Director Planning & Economic Development, Mike Pickering is urgently waiting advice regarding the extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)] and the shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping and Koala Priority Area boundary that will be applied across the Moreton Bay region.

Thanks in advance and please do not hesitate to contact me if required.

Regards

Robyn Moffat
Manager, Environmental Services
 Environmental Services Department
Moreton Bay Regional Council
 PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: Personal
E: robyn.moffat@moretonbay.qld.gov.au

From: Robyn Moffat
Sent: Tuesday, 24 September 2019 4:16 PM
To: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Cc: Kristy Gooding <Kristy.Gooding@lgaq.asn.au>; Crystal Baker <Crystal_Baker@lgaq.asn.au>
Subject: Request for clarification - Letter from Director General to MBRC

Hi Mandy,

In reference to the attached letter received by Council's Acting Chief Executive Officer, Graeme Kanofski could you please provide clarification on the below points. This will enable the team to update Directors and Councillors.

With reference to advice from the Director General that - "I have decided to include all existing koala habitat under the existing GHD mapping in order to ensure that more, rather than less, potential habitat is protected" could you please clarify:

1. The extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)]
2. Where will the above determined/defined mapping be applied?
 - o 2.1 Across the whole MBRC region or
 - o 2.2 Within the defined Koala Priority Area only
3. What planning provisions/regulation apply to the mapped areas, within and outside the Koala Priority Area (including the transitional areas). I have attached the previously provided draft trigger tables and your advice regarding the application of these is appreciated.
4. Where is the defined (final version) Koala Priority Area boundary for the Moreton Bay region?

Could you also provide, at your earliest convenience, shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping that will be applied across the Moreton Bay region and Koala Priority Area boundary so that we can load it into our GIS system for review (spatially).

With reference to the comment from the Director General that - "inclusion of these (mapped) areas may impact on achieving Shaping SEQ dwelling targets within MBRC.." could you please clarify:

5. Areas within the Moreton Bay region (growth areas/targets) that DES are aware of that will be impacted/influenced by the proposed mapping
6. The intent of the proposed planning provisions and exemptions regarding mapped koala habitat, specifically -
 - o 6.1 Development (within the Koala Priority Area) which purports to 'not require clearing of koala habitat', but approval of the development could result in subsequent clearing of koala habitat which is 'exempted development', will the (parent) development prohibited development?

Examples for context -

A subdivision proposes a new lot boundary within 4m of koala habitat. The development claims the koala habitat will be retained by the proposal. A future landowner may be able to clear the koala habitat as it accords with the 'exempted development' criteria. Will the original subdivision proposal be considered to be prohibited development?

A lot reconfiguration 'does not require clearing of koala habitat' but results in 500m2 lots which contain koala habitat. The koala habitat could subsequently be cleared as exempt clearing work (clearing of up to 500m2 of koala habitat). Will the lot reconfiguration be considered to be prohibited development?

With reference to the comment from the Director General's that - "Exemptions were also drafted to align (wherever possible) to the corresponding exemptions under the State's Vegetation Management Framework to avoid unnecessary inconsistencies." could you please clarify:

7. What the proposed provisions/regulations would be in the following circumstance -

A proponent has submitted an application to DNRM and have had their property assessed against the *Vegetation Management Act 1999*. The proponent has subsequently been provided with a PMAV that redefines their lot as "Category X" under the *Vegetation Management Act 1999*. The lot also contains mapped koala habitat (MSES - GHD mapping - as per the Moreton Bay Regional Council Planning Scheme).

 - 7.1 What are the koala habitat protection arrangements in this instance?
 - 7.2 Will the clearing of the koala habitat be prohibited?

Thank you for your advice. Please don't hesitate to give me a call should you require any further information or details regarding the above questions. I'll touch base with you later in the week.

Regards

Robyn Moffat
Manager, Environmental Services
 Environmental Services Department
Moreton Bay Regional Council
 PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: Personal
E: robyn.moffat@moretonbay.qld.gov.au

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Spatial modelling and planning for koalas in southern South East Queensland

Koala habitat mapping (HSM) v1.0

Koala Priority Areas (KPA) v1.0

Koala Habitat Restoration Areas (KHRA) v1.0

Locally Refined Koala Habitat Areas (LRKHA) v1.0

Report version 1.0

Prepared by: Biodiversity Assessment Team, Queensland Herbarium, Science and Technology Division, Department of Environment and Science

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Citation

Department of Environment and Science (DES) 24 September 2019. Spatial modelling and planning for koalas in southern South East Queensland: Report version 1.0. Koala habitat mapping (HSM) v1.0, Koala Priority Areas (KPA) v1.0, Koala Habitat Restoration Areas (KHRA) v1.0, Locally Refined Koala Habitat Areas (LRKHA) v1.0. Brisbane: Department of Environment and Science, Queensland Government.

Acknowledgements

The project team would like to acknowledge the invaluable contribution of the Koala Expert Panel, namely Associate Professor Jonathan Rhodes, Dr Alistair Melzer, Ms Antra Hood and Mr Al Mucci, and a specially formed Koala Advisory Group of koala ecologists and spatial modelling experts including; Associate Professor Jonathan Rhodes, Dr Alistair Melzer, Dr Hawthorne Beyer, Professor Clive McAlpine, and Dr Bill Ellis. Other members of the Biodiversity Assessment Team, DES, significantly contributed to the project. Sincere thanks goes to Stephen Trent who provided invaluable advice on the use of Maxent. Simon Goudkamp and Courtney Duncan provided valuable spatial scripting (Python) support, whilst Dr David McFarland provided technical and species advice and knowledge. Peter Scarth and Dan Tindal, DES, are thanked for their advice and knowledge regarding remote sensing. Dan Brough, DES, is thanked for assisting with soil data. The project team would like to acknowledge the time and effort taken by local government staff to compile and provide this information.

This report was prepared by: Harriet Preece, Leonie Seabrook, Courtney Duncan and Steven Howell.
24 September 2019.

Revision history

Version	Date	Description
1.0	24 September 2019	<p>This release includes the following:</p> <p>Core koala habitat suitability mapping (HSM v1.0), based on:</p> <ul style="list-style-type: none"> - Regional ecosystem mapping version 11, produced by the Department of Environment and Science, Queensland Herbarium. December 2018. - High Value Regrowth mapping, produced by the Department of Environment and Science, Queensland Herbarium. March 2019. - Application of regional ecosystem erase layer produced by the Department of Environment and Science, Queensland Herbarium. 6 September 2019. Used to remove areas of remnant identified as cleared since the previous regional ecosystem release. - Application of High Value Regrowth erase layer produced by the Department of Environment and Science, Queensland Herbarium. 23 August 2019. Used to remove areas of HVR identified as cleared since the previous High Value Regrowth release. - Removal of core habitat from islands (other than North Stradbroke, South Stradbroke and Bribie), that either don't contain koala records or would not be able to sustain a koala population. - Study area boundary based on South East Queensland Regional Plan 2017 'Shaping SEQ' (DILGP 2017). <p>Koala Priority Area (KPA) mapping (v1.0).</p> <p>Koala Habitat Restoration Areas (KHRA) mapping (v1.0).</p> <p>Locally Refined Koala Habitat Areas (LRKHA) mapping (v1.0).</p>

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Description	Version	GIS Name
Koala Habitat Suitability Model (HSM): Remnant and regrowth, core habitat	v1.0	koala_habitat_suitability_model_v1_0
Koala Priority Areas (KPA)	v1.0	koala_priority_areas_v1_0
Koala Habitat Restoration Areas (KHRA)	v1.0	koala_habitat_restoration_areas_v1_0
Locally Refined Koala Habitat Area (LRKHA)	v1.0	locally_refined_koala_habitat_areas_v1_0

List of abbreviations

Abbreviation	Description
AUC	Area under the ROC (receiver operating characteristic) curve
CEC	Cation exchange capacity
DEM	Digital elevation model
DES	Department of Environment and Science
DSDMIP	Department of State Development, Manufacturing, Infrastructure and Planning
DSITI	Department of Science, Information Technology and Innovation
EHP	Department of Environment and Heritage Protection
FPC	Foliage projection cover
GDE	Groundwater dependent ecosystem
ha	Hectare(s)
HSM	Habitat Suitability Model
HVR	High value Regrowth
KAG	Koala Advisory Group
KEP	Koala Expert Panel
kg	Kilogram(s)
KHRA	Koala Habitat Restoration Area
km	Kilometre(s)
KPA	Koala Priority Area
KPO	Koala Policy and Oversight team, Environmental Policy and Programs, DES
LGA	Local government area
LRKHA	Locally Refined Koala Habitat Area
m	Metre(s)
MASL	Metres above sea level
Maxent	Maximum entropy modelling
mm	Millimetre(s)
NDVI	Normalised difference vegetation index
PDA	Priority development areas

Abbreviation	Description
RE	Regional Ecosystem
REDD	Regional Ecosystem Description Database
ROC	Receiver operating curve
SDM	Species distribution model
SEQ	South East Queensland
SIR	Queensland Government's spatial information resource
SISP	Spatial imagery subscription plan
SLATS	Statewide Landcover and Trees Study
SMPK	Spatial modelling and planning for koalas in southern South East Queensland project
SRTM	Shuttle radar topography mission
VM Act	<i>Vegetation Management Act 1999 (Qld)</i>

Executive summary

One of the key recommendations of the Koala Expert Panel (KEP) was to develop targeted and high quality koala habitat and threat mapping that can be used to underpin a more coordinated and strategic approach to koala conservation in South East Queensland. The KEP recommended that the new koala habitat mapping should be suitable for monitoring changes in koala ecological values and threats over time and be suitable for supporting future policy and management decisions while addressing the limitations of previous mapping.

This report describes the development of new koala habitat mapping and the delineation of broad koala priority areas (KPAs) for koala conservation and habitat restoration (KHRA) and locally refined koala habitat areas (LRKHA).

New tenure-blind koala habitat mapping was developed to use state-of-the-art modelling coupled with the Queensland government's expertise in state-wide, comprehensive vegetation mapping. The approach integrated a species distribution model with the Queensland Herbarium's regional ecosystem (RE) mapping and validated koala occurrence records to produce a comprehensive map that ranked koala habitat values across the South East Queensland (SEQ) study area. The new approach used a set of key biophysical variables with statistically tested relationships to koalas to construct a distribution model linked to the regional ecosystem mapping. Linking the new koala habitat mapping with the government's existing vegetation and landcover mapping allows the modelling to be updated and refined as newer data becomes available.

To ensure the adequacy of any new mapping, the spatial modelling and planning for koalas in southern South East Queensland project (SMPK) received input and advice from the KEP and a specially formed koala advisory group (KAG) consisting of koala ecologists and spatial mapping specialists.

The new koala habitat mapping divided habitat into three categories (core habitat, non-core habitat, and non-habitat) across pre-clearing, remnant and non-remnant (regrowth) vegetation as delineated by the Queensland Herbarium, Department of Environment and Science (DES). In version 1.0 the focus is on core habitat, which is a subset of the full koala habitat suitability model (for further details see section 2). Core habitat represents the best habitat for koalas, based on the combination of biophysical measures, suitable vegetation and koala occurrence records. Other categories of non-core habitat that koalas may use as refuges from heat or fire, for thermoregulation (shade), or for dispersal and connectivity between populations and non-habitat, which refers to areas that are very unlikely to provide suitable conditions for supporting koala populations, are not included in version 1.0.

Koala habitat occurring in regrowth vegetation was delineated using the best source data currently available, which was the high value regrowth mapped by the Queensland Herbarium. Incorporating non-remnant habitat recognises the importance of these areas for koala conservation as koalas do not discriminate between intact or regrowth habitat and are known to use landcover ranging from remnant forests to individual trees in urban or rural settings. Datasets that are better able to reliably detect and map regrowth and even individual trees are likely to be available in the future with additional research and development by the Statewide Landcover and Tree Study (SLATS) program and other groups within DES including the Queensland Herbarium.

The koala habitat mapping from this project identified 518,757ha of remnant core koala habitat in the study area from a pre-clearing extent of 1,851,337ha. This represents a 72% reduction in the area of remnant core koala habitat. Of the best quality habitat, approximately 90% has been lost, with much of it situated on the high fertility, highly modified alluvial plains.

In addition to developing new koala habitat mapping, the KEP recommended that there was a need to undertake comprehensive threat mapping and to identify priority areas for koala conservation across rural and urban landscapes in SEQ. To achieve this, a comprehensive set of threats, constraints, opportunities and resilience measures were combined with the habitat mapping to assist with identifying priority areas that will be the focus of koala conservation measures. Spatial prioritisation software, Marxan, was used to identify broad priority areas for koala habitat protection and restoration based on the presence of existing remnant or regrowth vegetation or the potential for restoration based on former habitat. Areas with a combination of low threats and constraints, and high conservation opportunities were identified where koala conservation measures would be more likely to achieve desired outcomes. Both habitat protection and areas targeted for restoration were focused within the KPAs. Areas for prioritising threat management were also identified to help guide targeted management actions.

1 Introduction

In Queensland, koala populations are in decline with the species listed as vulnerable by the Queensland Government under the *Nature Conservation Act 1992* and by the Australian Government under the *Environment Protection and Biodiversity Conservation Act 1999*. In South East Queensland (SEQ), despite existing protection strategies, koala numbers have decreased by 50–80% in key habitat areas over the last 20 years with this rate of decline possibly accelerating (Rhodes et al. 2015). Increases in the number of people living in SEQ and the associated loss of habitat is putting added pressure on koala populations already subject to high mortality caused by vehicle collisions, dog attacks and disease.

New approaches are therefore needed to better protect koalas, especially in the south-east, where the state's largest koala population is living in close proximity to large urban centres. In May 2016 the then Minister for Environment and Heritage Protection, National Parks and the Great Barrier Reef announced the establishment of a koala expert panel (KEP) and consultation with specialists with a diversity of expertise in relation to koala population dynamics, genetics, captive breeding, translocation, disease management, threat mitigation, rescue and rehabilitation, town planning and behavioural science. The consultation identified a number of key ongoing issues which threaten koala populations in SEQ, including matters relating to strategic policy settings, threat management, planning processes, monitoring and mapping (KEP 2017).

Reviews of earlier koala habitat mapping identified a number of strengths and limitations of previous approaches (Neldner and Accad 2013; Rhodes 2014; EHP 2017). Major limitations included a lack of comprehensiveness, coarse resolution, simplistic habitat associations, and no update mechanisms (Rhodes et al. 2017). Previous mapping has used broad landcover associations and biophysical properties such as land zone, slope and elevation with koala occurrence records to characterise habitat quality (GHD 2009). Other mapping has used tree species preferences as the primary driver of koala habitat quality and often ignored landscape-level processes such as fragmentation (Rhodes 2014). The KEP highlighted the strengths and complementarity of earlier methods and recommended that future mapping could benefit from using state-of-the-art species habitat modelling and adopting the best aspects of the previous landcover and vegetation-centred approaches (Rhodes et al. 2017).

The spatial modelling and planning for koalas (SMPK) in southern South East Queensland project was established to deliver koala habitat mapping based on the latest scientific modelling principles and data. The project set out to develop a tenure-blind koala habitat mapping framework based on the integration of biophysical variables with an expert derived vegetation classification and records of koala occurrence. The approach integrated a species distribution model (Guisan and Thuiller 2005) with the Queensland Herbarium's regional ecosystem (RE) mapping and validated koala occurrence records to produce a comprehensive map that ranks koala habitat values across the study area.

The model used the machine learning program, Maxent (Phillips et al. 2006), and a set of decision rules (matrix) to determine which areas were considered core habitat, non-core habitat and non-habitat across pre-clearing, remnant and non-remnant (regrowth) vegetation in SEQ. For this version 1.0, only core habitat was used. Linking the new koala habitat mapping with the government's existing vegetation and landcover mapping programs allows the modelling to be updated and refined as updated high resolution remnant and non-remnant data becomes available. The potential habitat values of cleared or partially cleared areas can be derived from the pre-clearing modelling and used as a valuable tool for targeting restoration measures in areas of the highest koala habitat suitability.

Comprehensive threat mapping was also carried out to support the identification of broad-scale priority areas for koalas across rural and urban landscapes in SEQ. Threats, constraints, opportunities and resilience measures were evaluated and used as inputs for the spatial prioritisation software, Marxan, to identify broad priority areas to target koala habitat conservation. Specific Koala Priority Areas (KPAs) were then developed from the Marxan models. KPAs will be used to develop policy for koala conservation around habitat protection and habitat restoration opportunities.

The project received input and advice from the KEP and a specially formed project-specific koala advisory group (KAG) consisting of koala ecologists and spatial mapping specialists. The study area for the project was defined by the SEQ regional planning area, represented by 12 local government areas (LGAs).

1.1 Project Scope

The SMPK project involved:

- Collation of literature, koala occurrence records, spatial data and approaches for modelling habitat suitability for koalas.

- Evaluation of koala habitat suitability using a repeatable, transparent modelling approach that included a suite of biophysical, habitat and threat drivers of koala distribution and density.
- Consultation with relevant local governments, state government, universities and natural resource management groups to acquire data on threats, constraints, opportunities and resilience relevant to koala conservation to inform the identification of priority areas for koala conservation.
- Engagement with internal and external experts (KEP and KAG).
- Application of the method to the SEQ regional planning area.
- Identification of areas for future monitoring and field surveys to evaluate and validate the results.

1.2 Study area

The study area corresponds to the South East Queensland Regional Plan 2017 “Shaping SEQ” (DILGP 2017), encompassing 12 local government areas: Noosa, Sunshine Coast, Moreton Bay, Brisbane, Redland, Logan, Ipswich, Gold Coast, Somerset, Lockyer Valley, Scenic Rim, and a portion of Toowoomba (Figure 1).

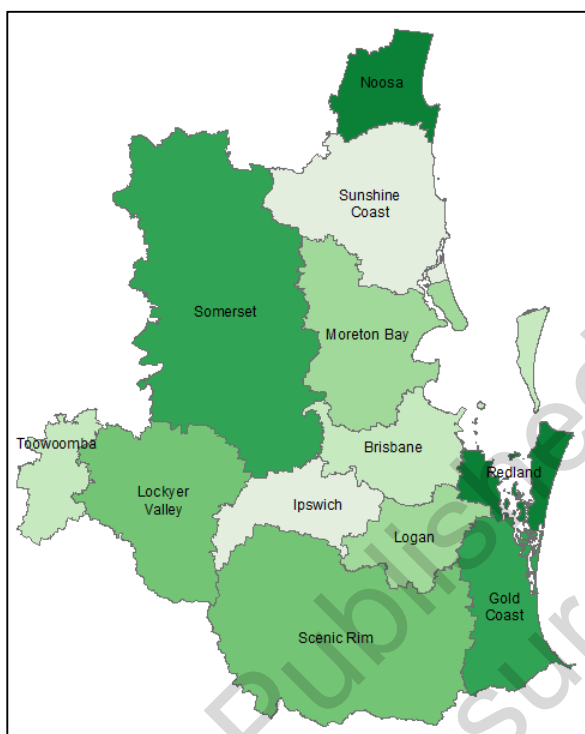


Figure 1: SEQ study area showing the twelve local government areas within the regional planning area.

1.3 Consultation

The project undertook consultation with the 12 local governments within the study area, in order to acquire the most current data available. The consultation targeted the acquisition of specific koala conservation and occurrence data relevant to the project. Consultation included requesting information about koala conservation measures, programs and data specific to each of the LGAs, including:

- Koala records – additional occurrence records not held currently in the Department of Environment and Science (DES) databases. These records will be provided to WildNet.
- Koala conservation areas – spatial layers or descriptions of areas where local governments are investing in koala conservation to ensure the project took into account identified priority areas for on-ground works, or where the councils have identified priority areas for koalas or biodiversity corridors.
- Parks and reserves – including other conservation covenant and agreement lands such as Land for Wildlife properties that could provide synergies with koala conservation measures.
- Conservation constraints – areas identified for future urban development or other constrained areas that would reduce the success of implementing koala conservation measures.

A larger consultation process was undertaken on broader koala conservation issues by DES and was reported in the KEP final report (KEP 2017).

1.4 Conceptual model

A conceptual model was developed for the project with components including: spatial modelling, modelling summary, deliverables and decision framework (Figure 2). The spatial modelling component was used to identify the three main criteria in the project:

1. Koala habitat
2. Threats and constraints
3. Opportunities and resilience

Koala habitat mapping was the first major component of the project followed by modelling of threats, constraints, opportunities and resilience. The outputs were combined and incorporated in a decision framework to identify broad-scale priority areas for koala habitat protection, restoration and threat management.

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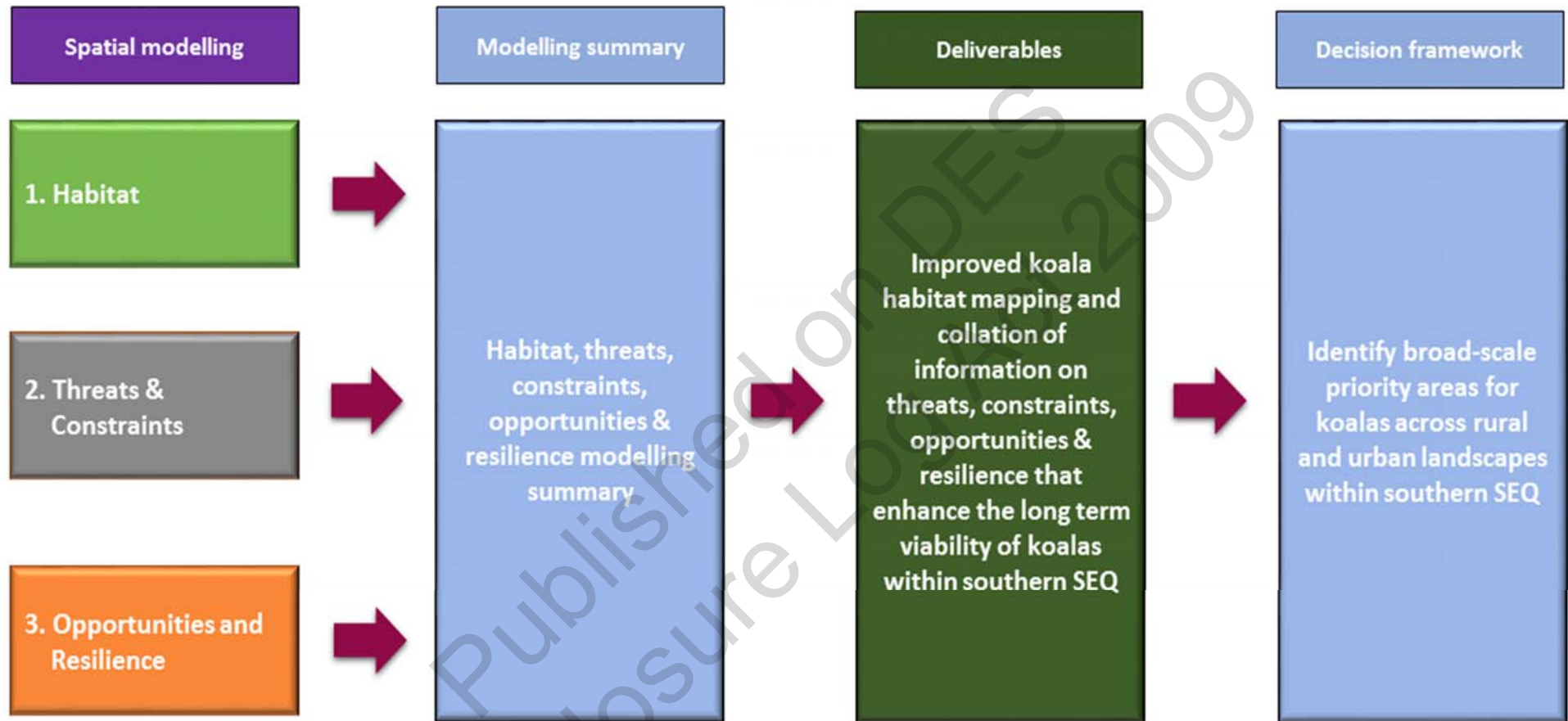


Figure 2: Conceptual model.

2 Koala habitat suitability model

The new koala habitat mapping was developed to represent the habitat *niche* or habitat most suitable for the species (Araújo and Guisan 2006). The method was developed to be robust, easily repeatable and to ensure outputs were as up-to-date and transparent as possible. The method used state-of-the-art modelling coupled with the Queensland government's expertise in state-wide, comprehensive vegetation mapping. It integrated a species distribution model with the Queensland Herbarium's RE mapping and validated koala occurrence records to produce a comprehensive map that ranked koala habitat values across the SEQ study area.

The new approach used a set of key biophysical variables with statistically tested relationship to koalas to construct a distribution model linked to the RE mapping. Linking the new koala habitat mapping with the government's existing RE mapping overcame the coarse resolution issues and major limitations of the previous approaches by allowing for regular revisions tied to updates by the Queensland Herbarium.

The method was developed to be easily adaptable to other regions through the inclusion of regionally specific datasets and rules. To ensure consistency and repeatability, no manual editing was undertaken. To ensure transparency, users are able to drill down through the attributes for each polygon to obtain the values from each phase of the modelling. The project builds on data and approaches used in previous koala habitat mapping and reviewed prior to this modelling project (EHP 2017). Comprehensive details of the GIS processing methods are described in a supplementary document (DES 2019).

2.1 Approach

Koala habitat was modelled using a three stage approach. In the first stage, a RE suitability classification was developed that used expert knowledge of koala habitat preference to identify the type of habitat that koalas prefer. In the second stage, a species distribution model (SDM) was developed using Maxent (Phillips et al. 2006) and key biophysical variables with a statistically tested relationship to koalas. In the third stage a decision matrix was developed to integrate both the RE suitability classification from the first stage and the Maxent model from the second stage, in combination with koala occurrence records. Figure 3 illustrates how each stage feeds into the decision matrix and contributes to identifying the habitat categories.

The new koala habitat mapping divided habitat into three categories: (1) core habitat, (2) non-core habitat and (3) non-habitat. For version 1.0 only core habitat was included. The mapping was applied across pre-clearing, remnant and non-remnant (regrowth) vegetation. Incorporating non-remnant habitat into the mapping recognises the importance of these areas for koala conservation as koalas do not discriminate between intact or regrowth habitat and are known to use landcover ranging from remnant forests to individual trees in urban or rural settings.

Datasets that are better able to reliably detect and map regrowth and individual trees will be available in the future with additional research and development by the Statewide Landcover and Tree Study (SLATS) program and other groups within DES. Establishing a mapping framework which includes regrowth was considered important in order to provide scope for future technological and methodological improvements.

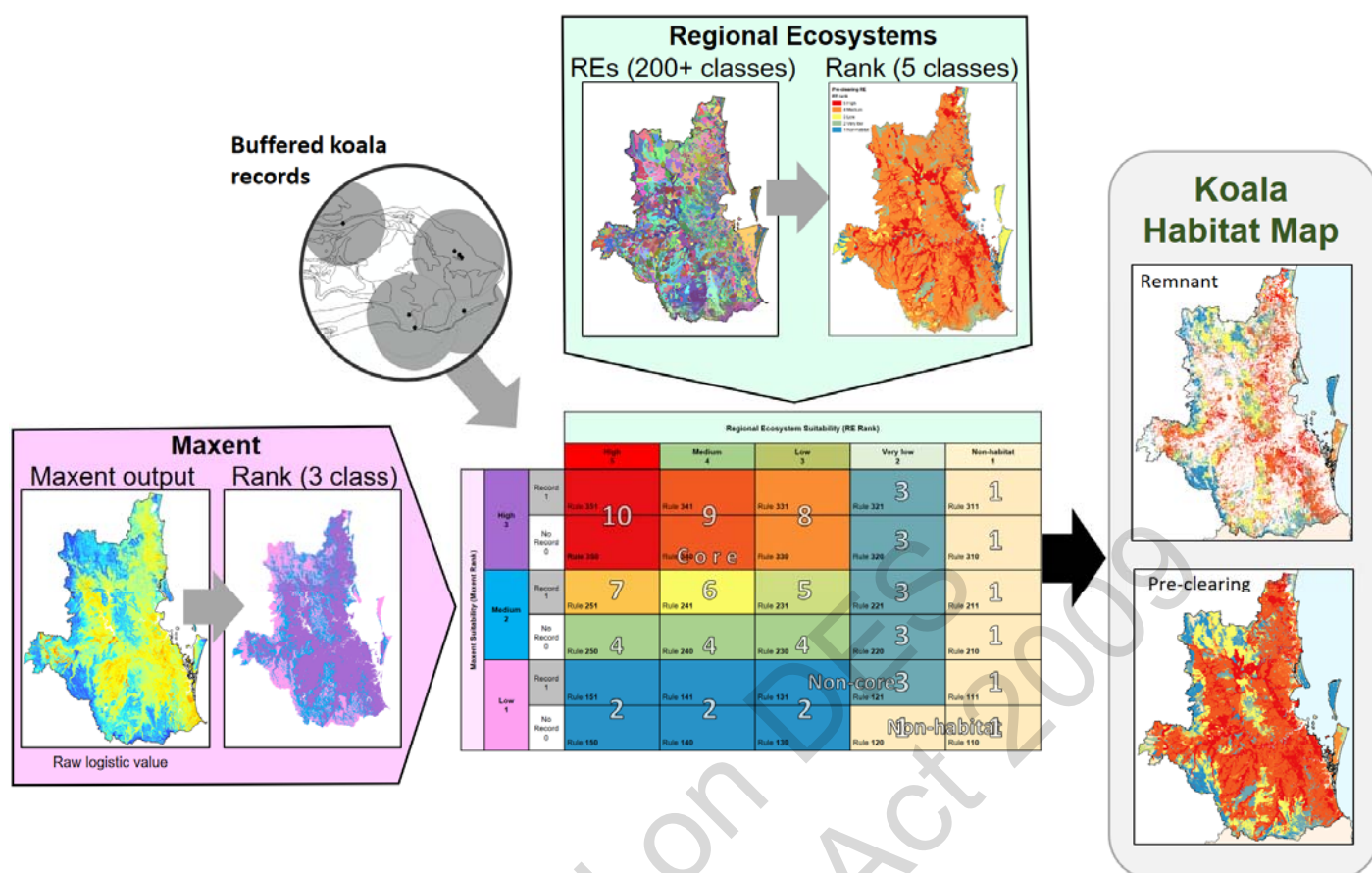


Figure 3: Modelling approach used in identifying koala habitat suitability.

2.2 Data sources

The mapping used an extensive set of spatial data layers that were chosen based on their known and potential relationships with koala distribution and abundance. The data layers represented key biophysical drivers of koala habitat. To ensure the method was repeatable, transparent and more broadly applicable, a further consideration for inclusion of data layers was based on availability and the need for datasets to be broadly mapped across the whole study area, approved and published on the Queensland Government Spatial Information Resource (SIR) data repository and hence likely to be available should they be needed for future analysis. All data sets were prepared using ArcGIS v10.4.1, 10.5 & 10.6 (ESRI Redlands, CA, USA).

To undertake the analysis, data was organised into three tiers: criteria, indicators, and measures. For the koala habitat criterion, environmental measures (variables) represented indicators of vegetation, terrain, soil, climate, landcover, and groundwater (Figure 4).

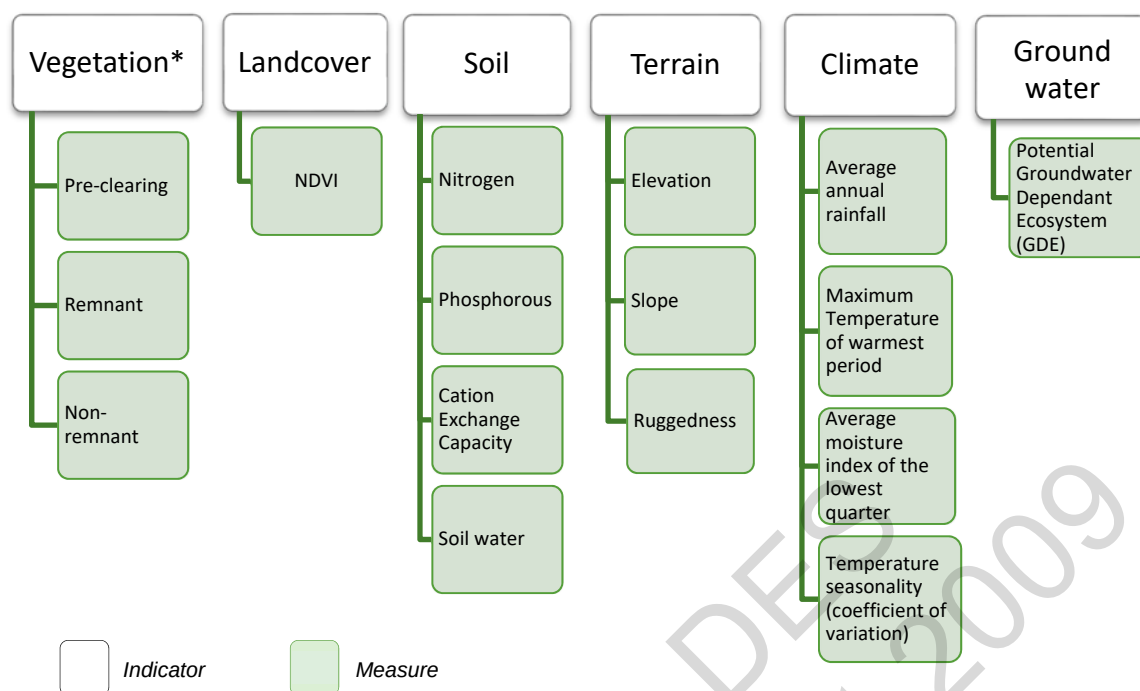


Figure 4: Indicators and measures used for the habitat criterion in the koala habitat spatial model.

*Vegetation was considered in the matrix stage, all other measures were considered in the Maxent modelling.

2.3 Koala occurrence records

Koala occurrence records were collated and vetted prior to producing a dataset with 80,249 records with coordinate precision $\leq 900\text{m}$ and year of observation between 1975 and 2018 (inclusive)¹. Of the records used, 90% were from the past 21 years i.e. since 1996. Records were vetted for spatial accuracy and duplicates removed before being subset to obtain a dataset for the SEQ study area (Figure 5). The majority of the records (93%) had a recorded coordinate precision better than 500m, with 2% of the records having a precision of 100m, 91% having a precision of 500m and 7% having a precision of 900m. Maxent is relatively insensitive to spatial errors associated with location data and has been shown to perform well with errors up to 5km (Graham et al. 2008). Records were collated from numerous sources, including incidental and systematic survey data (Appendix 2). The records used in the project were sourced as follows:

- 54% from the Queensland Fauna Database held by DES which contains vetted Queensland fauna records from various contributors. QHFD incorporates records from WildNet and Queensland Biodiversity and Ecological Research Database (QBERD).
- 27% from koalaBase which contains records from koala hospital databases.
- 14% from local government authorities and Lockyer community group.
- 5% from DES systematic survey data and additional WildNet data.
- 1% from Atlas of Living Australia.

¹ Using fauna records collected since (and including) 1975 and with a coordinate precision less than and including 900 m is consistent with existing habitat suitability modelling and the biodiversity assessment mapping methodology (EPA 2004; EHP 2014).

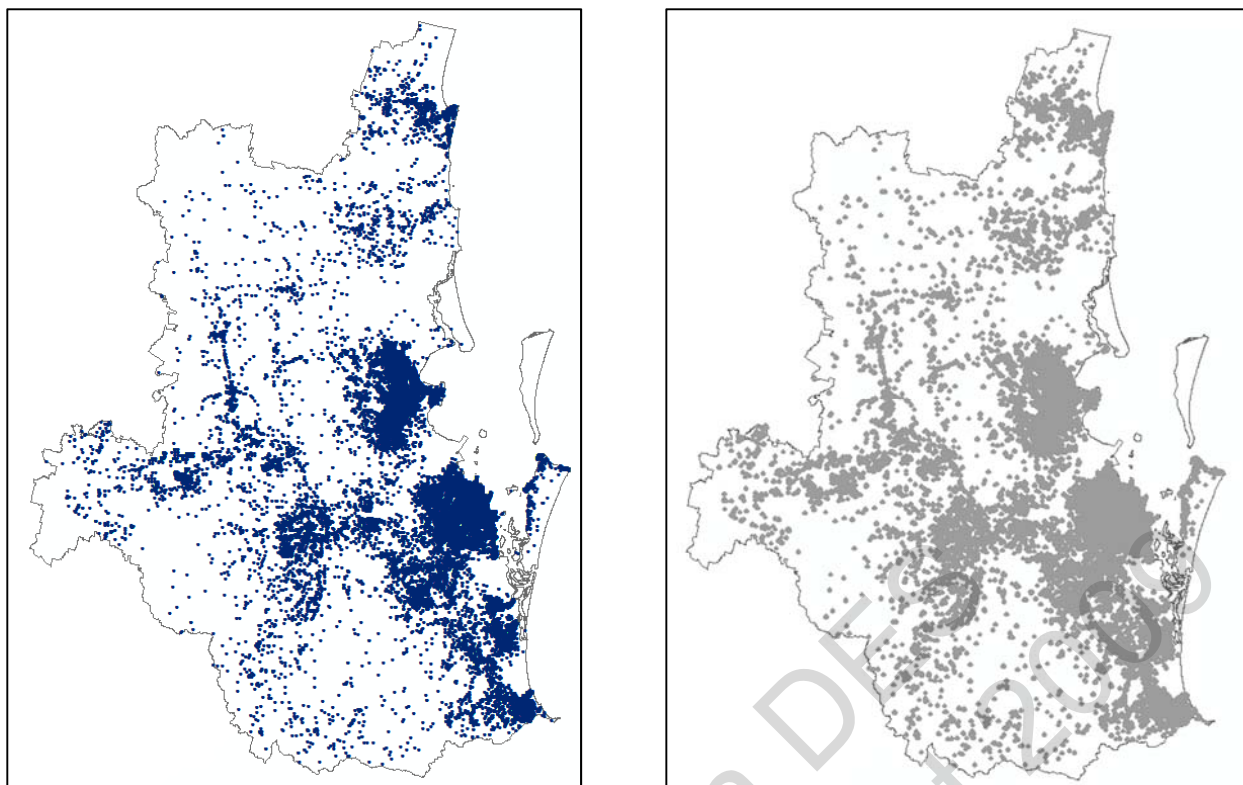


Figure 5: Koala occurrence records (a) and 900m buffer (b).

A detailed description of the sources of koala data collated for the project is provided in (Appendix 2). The 80,249 vetted records were used to develop the habitat matrix. A much smaller, random subset of spatially filtered records was used to reduce survey bias during the development of the Maxent model (Appendix 6).

To construct the habitat matrix the koala records were buffered by 900m to create a polygon dataset representing the full set of vetted occurrence records. The buffered koala records dataset was then intersected with regional ecosystem polygons. The presence (1) or absence (0) of the koala record buffer was recorded in the attributes for every regional ecosystem polygon to facilitate interrogation and increase data transparency. A 900m buffer was used because it is equivalent to the coordinate precision used in the record vetting process and in other habitat suitability models (EPA 2004). The buffer diameter of 1800m is close to the median dispersal distance of approximately 2km recorded for koalas in South East Queensland (Dique et al. 2003) and representative of a home range of 254ha, similar to a large home range of 296ha recorded for koalas in central Queensland (Ellis et al. 2002).

2.4 Regional ecosystem suitability categorisation

The RE classification ranked the koala habitat suitability of each RE occurring in the study area. This was achieved by consulting experts from the KAG and assisted by information relating to the presence and relative dominance of trees used by koalas, the number of koala records for each RE, and the percentage of RE polygons with koala records.

2.4.1 Regional ecosystem suitability classification

The presence and relative dominance of utility tree species within the RE description provided by the Regional Ecosystem Description Database (REDD) was used to help experts classify each RE into one of five RE suitability classes: high, medium, low, very low and non-habitat. Categorisation was further refined by checking the number of occurrence of koala records within each RE as well as the percentage of polygons of the same RE with koala records. For example, if a regional ecosystem consisting of 150 polygons had 60 koala records recorded from 30 polygons, then the percentage with koala records would be 20%. To ensure consistency, the allocated RE suitability classification was checked against previous expert rankings undertaken for other koala habitat models (EHP 2016). The suitability classification of the majority of REs was consistent with previous ranking and any discrepancies were flagged for further detailed examination and provided to the KAG for feedback. In the majority of cases, discrepancies were attributed to differences

in the number of koala records or the occurrence of a high utility species within the RE description. See Appendix 3 for the results of the RE classification.

2.4.2 Tree species utility

The process of assigning tree species utility value involved classifying the tree species listed in the full RE descriptions from the Regional Ecosystem Description Database for those REs occurring within the study area, into one of four utility classes (Table 1). The initial assessment was conducted using REDD v10 (Queensland Herbarium, 2016) and subsequently updated. See Appendix 4 for the results of the tree utility classification.

Table 1: Tree species utility classes used to help rank the regional ecosystems.

Tree species utility class	Description
Higher	Species referred to in a variety of reports and literature, the majority of which were definitive studies, described as being an important utility species for koala.
Medium	Species referred to in some reports and literature, can be secondary or anecdotal reference to species used by koalas e.g. species included in a factsheet.
Lower	Species not referred to in any literature or considered a trace food species for koalas from a definitive study, and/or eucalypt.
None or unknown	Species not referred to in any literature, not eucalypt, melaleuca or lophostemon.

The Queensland Herbarium's RE mapping was then attributed with the RE suitability. The mapping contains both homogeneous (one type of RE) and heterogeneous (mixed REs) polygons. In the case of heterogeneous polygons, the polygon was attributed with the highest RE suitability category represented in the polygon. This precautionary approach was taken to ensure that areas that contained highly suitable vegetation types for koalas were captured in the modelling. Appendix 5 provides a worked example of the RE suitability classification process.

2.4.3 Vegetation cover classes

Recognising the importance of both remnant and non-remnant habitat to koalas, the habitat model was applied to pre-clearing and remnant vegetation (as delineated by the Queensland Herbarium, DES) and non-remnant regrowth vegetation (Appendix 1). Recent and historical clearing has often focussed on the lower alluvial, highly productive areas in the landscape which frequently coincided with the best habitat for koalas. As a result, much of the remnant vegetation now only occurs in lower productivity areas, such as the dry hills and ranges, which are often less suitable habitat for koalas. Koalas are known to prefer palatable vegetation and may in fact preferentially select individual trees or regrowth vegetation because these areas often have a larger proportion of young trees with more palatable leaves and higher nutritional value than mature remnant forest with large trees (Braithwaite et al. 1984; Cork et al. 1990; Cork and Braithwaite 1996; Cork et al. 2000; Moore et al. 2004; Lunney et al. 2000). The ability to identify different vegetation cover classes was considered important for management where areas of regrowth could be focal points for potential habitat restoration efforts. Consequently, the koala habitat mapping was applied across a total of three different vegetation cover classes, as follows:

1. Pre-clearing

Pre-clearing vegetation is defined as the vegetation present before clearing and represents the pre-European vegetation prior to major impacts by non-indigenous people. Pre-clearing vegetation is mapped by the Queensland Herbarium, DES, using historical aerial photographs in conjunction with field surveys as described in Neldner et al. (2019).

2. Remnant

Woody vegetation is mapped as remnant where the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum

and is dominated by species characteristic of the vegetation's undisturbed canopy. Remnant vegetation is mapped by the Queensland Herbarium, DES, using aerial photography and Landsat TM satellite imagery supplied by SLATS in conjunction with field surveys as described in Neldner et al. (2019).

3. Regrowth

Regrowth is non-remnant vegetation that has a significant woody component but fails to meet the structural and/or floristic characteristics of remnant vegetation. It includes vegetation that has regrown after clearing or vegetation that has been heavily thinned or logged but may retain significant biodiversity values (Neldner et al. 2019). High Value Regrowth (HVR) mapping represents high conservation value native woody vegetation that has not been cleared for at least 15 years and was released by the Queensland Herbarium in December 2018 (Tim Ryan 2019, personal communication, 8 February). The regrowth layer was attributed with the regional ecosystems and koala habitat suitability rankings from the pre-clearing RE mapping.

2.5 Species distribution modelling

2.5.1 Maxent modelling

Koala habitat suitability was modelled using maximum entropy species geographic distribution modelling software (Maxent). Other species modelling approaches were investigated, however Maxent was recommended by the KEP and considered to be the most applicable approach given that the majority of records across the study region were non-systematic and consisted of occurrence records rather than systematic surveys that include absence data and information on prevalence. Maxent is a widely used machine learning program for generating species distribution models based on presence-only species records (Elith et al. 2006; Phillips et al. 2006). It has gained popularity for use in species modelling due to its ability to make predictions from incomplete information, such as the common scenario where systematic survey data is not available. Maxent predicts species occurrences by comparing the biophysical attributes at presence locations with a large sample of background point locations randomly generated across the study area.

In consultation with the KEP and KAG, the project team undertook an extensive process of compiling environmental variables (measures) on the basis of known or hypothesised links to koala habitat and ecology. Additionally, data sources needed to be available and mapped at an appropriate resolution (scale) across the study area. The environmental measures represented indicators of terrain, soil, climate, landcover, vegetation and groundwater (Table 2). An examination of correlations among the candidate measures and a pilot Maxent analysis were used to reduce the initial set of 18 variables to a final set of 13 measures used to build the model (Appendix 6). Following trials using a bias grid and spatial filtering at three spatial scales, a 2km hexagon grid (400ha) was used to reduce survey bias in the occurrence records prior to modelling using a 1ha (100m x 100m) grid cell with 1364 presence records and 10,000 randomly generated background points. For details of the Maxent modelling see Appendix 6.

Table 2: The final set of explanatory measures used in the Maxent model.

Indicator	Measure	Measure code	Short description
Soil	Nitrogen	hsnit	Mean mass fraction of total nitrogen in the soil by weight (%)
Soil	Phosphorous	hspho	Mean mass fraction of total phosphorus in the soil by weight (%)
Soil	Cation Exchange Capacity (CEC)	hscec	Concentrations of cations (cmol (+)/kg)
Soil	Soil water	hswat	Mean plant available water (mm)
Terrain	Elevation	htele	Mean altitude (m)
Terrain	Slope	htslo	Mean slope (degrees)

Indicator	Measure	Measure code	Short description
Terrain	Ruggedness	htrug	Topographic ruggedness (index)
Climate	Rainfall	hcapr	Annual average mean precipitation per year (mm/year)
Climate	Temperature	hctem	Maximum temperature of warmest period (°C)
Climate	Moisture index	hcmil	Moisture index - lowest quarter mean (index)
Climate	Temperature seasonality	hctsv	Temperature coefficient of variation (index)
Landcover	Normalised Difference Vegetation Index (NDVI)	hln dv	Representing living green vegetation (index)
Ground water	Groundwater Dependant Ecosystem (GDE)	hgpot	Ecosystems which require access to groundwater on a permanent or intermittent basis (category)

To construct the habitat matrix, the Maxent logistic values² from the model output were categorised into three classes (high, medium and low) representing koala habitat suitability based on a high and low logistic threshold (Table 3).

Table 3: Classification of Maxent logistic values used for constructing the habitat matrix.

Maxent classification rank	Maxent logistic value
3. High	0.460 – 1
2. Medium	0.299 – 0.459
1. Low	0 – 0.298

2.5.2 Maxent model validation

The accuracy of the Maxent model was assessed by creating a confidence map using 100 repetitions of the Maxent model (from a random sample of koala records) and repeated sub-sampling. Sub-sampling was undertaken whereby the presence points were repeatedly split into random training and testing subsets, with 80% of occurrence records used to train the model and 20% used to test the model (an approach cautiously supported by Araújo et al. 2005). Assessments were made using: (a) area under the ROC (receiver operating characteristic) curve (AUC) as a measure of model performance, (b) analysis of the variability associated with the predictor variables, (c) analysis of the response curves of the predictor variables, (d) mean habitat suitability and standard deviation, (e) visual interpretation of mapped predictions. For results of model validation see Appendix 6.

2.6 Koala habitat decision matrix

A koala habitat decision matrix (Stage 3) was used to create the koala habitat map by integrating the categorised output from the Maxent model (Stage 2) with the RE suitability classification and buffered koala

² The threshold between high and medium suitability was defined using the logistic value at which the sum of sensitivity and specificity is maximized (Liu et al. 2005; 2013). This approach minimizes the mean error rate for positive observations and the error rate for negative observations (false positives and false negatives) and is equivalent to finding the point on the receiver operating characteristic (ROC) curve whose tangent has a slope of one (Cantor et al. 1999; Freeman and Moisen 2008). The threshold between medium and low suitability was defined using the logistic threshold representing the 10 percentile training presence (Liu et al. 2005; 2013). This threshold defines the minimum probability of suitable habitat and using this threshold defines suitable habitat to include 90% of the data used to develop the model (Liu et al. 2005; Young et al. 2011). Low suitability was defined as logistic values below the 10 percentile training presence.

records (Stage 1). The decision matrix established the rules for categorising different classes of koala habitat and for version 1.0 was used to designate **core habitat** based on the application of the koala habitat decision matrix rules (Figure 6). The mapping for version 1.0 was applied only to remnant regional ecosystems and high value regrowth.

These rules were based on those applied in other koala habitat models (EPA 2004, EHP 2016) and through consultation with the KAG. The koala occurrence records, buffered by 900m, were used to confirm the likelihood of known and possible koala habitat and differentiate between core habitat and non-core habitat. The original 30 rules were grouped into 10 ranked from lowest suitability (rank 1) to the highest (rank 10)³ (Figure 7).

Core habitat – matrix categories 4 to 10

Core habitat refers to the best habitat for koalas, based on the combination of biophysical measures, suitable vegetation and koala occurrence records. Core habitat was delineated where there was agreement between the REs ranked high, medium or low suitability by the KAG and Maxent areas ranked high or medium suitability (with or without a koala record).

2.6.1 Koala habitat map

To produce the final koala habitat map (see Figure 3), the koala habitat categories from the decision matrix were allocated to the current regional ecosystem mapping units. Every regional ecosystem polygon was assigned a koala habitat value according to the rules in the decision matrix. The regional ecosystem mapping units and line-work were not altered, instead, each polygon was attributed with values associated with its utility to koalas. Using the regional ecosystem mapping as the point of truth ensured consistency with existing statutory instruments, such as Essential Habitat under the VM Act, which designates regional ecosystems as a mandatory essential habitat factor for koalas.

To increase the transparency of the model, each regional ecosystem polygon was attributed with its decision rule, regional ecosystem suitability (rank 1–5), Maxent suitability (rank 1–3) and presence or absence of a koala record buffer (1 or 0 respectively). For homogenous regional ecosystem polygons (containing only a single regional ecosystem), it was a straightforward process of assigning the regional ecosystem suitability designated by the experts directly to the polygon (see Appendix 3).

For heterogeneous polygons (containing more than one regional ecosystem), assigning the regional ecosystem suitability was achieved by attributing the polygon with the highest regional ecosystem suitability category represented in the polygon. Given that the Queensland Herbarium prescribe that a vegetation unit must occupy at least 5% of a polygon in order to be mapped, this effectively means that the regional ecosystem suitability given to a heterogeneous polygons was achieved using a 5% allocation threshold. For example, a heterogeneous polygon that consisted of 5% high and 95% low ranked regional ecosystems would be categorised as high rank. From an ecological perspective, if a polygon was heterogeneous then a koala is likely to use the favourable habitat components even if they occupy only a small proportion of the polygon. Consequently, using a precautionary approach, heterogeneous polygons containing small proportions of favourable conditions should be regarded as koala habitat.

The translation of raster Maxent values into vector regional ecosystem polygons was achieved using a 20% allocation threshold, so that each regional ecosystem polygon was populated with the highest Maxent ranked component that occupied 20% or more of that polygon. For example, a regional ecosystem polygon that consisted of 20% high and 80% low Maxent ranked components would be categorised as high Maxent rank.

The 20% Maxent allocation threshold was chosen to ensure that the majority of known habitat, (i.e. habitat confirmed by buffered koala records) was represented in the mapping. The 20% Maxent threshold captured 95% of the highest suitability koala habitat class and balanced the amount of habitat captured with the amount of known habitat not captured as core habitat. A higher threshold would decrease the total area

³ The full koala habitat model included **Non-core (marginal habitat) - matrix category 2** which represents areas of lower quality habitat that koalas can use but which are unlikely to sustain koala populations in the long term because of limiting environmental conditions; **Non-core (rainforest habitat) - matrix category 3** which represents habitat used by koalas for shelter and short-term refuge from threats and stressors such as heat and fire; and **Non-habitat - matrix category 1**, which refers to areas such as rock pavements, grasslands and mangroves that are considered very unlikely to provide habitat or contain koalas. Koalas may rarely be present in these areas, however, the areas do not represent koala habitat.

designated as core habitat at the expense of known high value habitat confirmed by koala records⁴. In this scenario we chose precautionary thresholds to ensure that areas of known habitat were, in the majority of cases, represented in the mapping.

To process the rules, the Maxent output was vectorised (converting the three raster classes into polygons), and intersected with the regional ecosystems and point record buffers. The koala habitat categories were then allocated using the 20% Maxent allocation threshold and the rules established in the habitat matrix.

Recording the matrix components and proportions within the polygon attributes increased the transparency of the model and allows users to drill down through the data table for each regional ecosystem polygon to obtain all the information used by the decision rules to allocate the core koala habitat categories⁵.

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⁴ Other approaches such as simple majority were also examined. Populating the regional ecosystem polygons with the Maxent class occupying the largest proportion of a polygon resulted in the failure of significant areas of known koala habitat being designated as core habitat. For example, if a regional ecosystem polygon was 45% high and 55% low Maxent rank then that polygon would not be designated as core habitat – even though it contained a large proportion of highly suitable habitat.

⁵ Processing was undertaken using ArcGIS (version 10.4) and a python script (“fauna – Phascolarctos SEQ political region” in the HSM_Toolbox) developed for this project.

			Regional Ecosystem Suitability (RE Rank)				
			High 5	Medium 4	Low 3	Very low 2	Non-habitat 1
Maxent Suitability (Maxent Rank)	High 3	Record 1	Rule 351	Rule 341	Rule 331	Rule 321	Rule 311
		No Record 0	Rule 350	Rule 340	Rule 330	Rule 320	Rule 310
	Medium 2	Record 1	Rule 251	Rule 241	Rule 231	Rule 221	Rule 211
		No Record 0	Rule 250	Rule 240	Rule 230	Rule 220	Rule 210
	Low 1	Record 1	Rule 151	Rule 141	Rule 131	Rule 121	Rule 111
		No Record 0	Rule 150	Rule 140	Rule 130	Rule 120	Rule 110
			Core				
			Non-core			Non-habitat	

Figure 6: Decision matrix and model rules used to define core habitat, non-core habitat and non-habitat.

			Regional Ecosystem Suitability (RE Rank)				
			High 5	Medium 4	Low 3	Very low 2	Non-habitat 1
Maxent Suitability (Maxent Rank)	High 3	Record 1	Rule 351 10	Rule 341 9	Rule 331 8	Rule 321	Rule 311
		No Record 0	Rule 350 10	Rule 340 9	Rule 330 8	Rule 320	Rule 310
	Medium 2	Record 1	Rule 251 7	Rule 241 6	Rule 231 5	Rule 221	Rule 211
		No Record 0	Rule 250 4	Rule 240 4	Rule 230 4	Rule 220	Rule 210
	Low 1	Record 1	Rule 151	Rule 141	Rule 131	Rule 121	Rule 111
		No Record 0	Rule 150	Rule 140	Rule 130	Rule 120	Rule 110

Core (Categories 4-10)

Non-core (Categories 1-3)

Non-habitat (Category 1)

Figure 7: Koala habitat decision matrix and ranked habitat suitability categories.

Decision matrix classes are ordered into 10 categories from (1) lowest suitability to (10) highest suitability. Categories 4–10 represent core habitat, with categories 4 and 5 the lowest suitability core habitat and category 10 the highest suitability core habitat.

2.6.2 Validation of koala habitat mapping

The following approaches were used to assess the accuracy of the draft koala habitat mapping:

1. Point validation – compared an independent set of koala records ($n = 264$) with the mapped habitat using supplementary koala survey records (not used in model development) sourced from:
 - a) GHD field verification (GHD 2009) – 490 points (96 presence, 394 absence).
 - b) McAlpine Noosa data (McAlpine et al. 2008) – 300 points (114 presence, 186 absence).
 - c) Rhodes SEQ data (Rhodes et al. 2006) – 133 points (54 presence, 74 absence).
2. Stratified random sampling – compared the mapped habitat with high-resolution digital photography using a set of random points. The accuracy of the Koala Habitat Map was assessed using a set of 200 random points which were allocated to the mapped cover types using stratified random sampling as follows: 100 points in remnant and 100 points in non-remnant. Accuracy assessment was made by manually comparing the mapped cover classes representing trees with high resolution, recent imagery provided through the Spatial Imagery Subscription Plan (SISP).

2.7 Results

2.7.1 Regional ecosystem suitability categorisation

The 209 REs occurring in the SEQ study area were classified according to their suitability as koala habitat into five suitability classes shown in Figure 8. The koala habitat suitability of each RE in the SEQ study area and the RE description is given in Appendix 2. The extent of each RE class emphasises the strong relationship between high RE suitability and lowland or alluvial landforms, which are preferentially cleared for human uses. For estimates of changes in koala habitat see section 2.7.4.

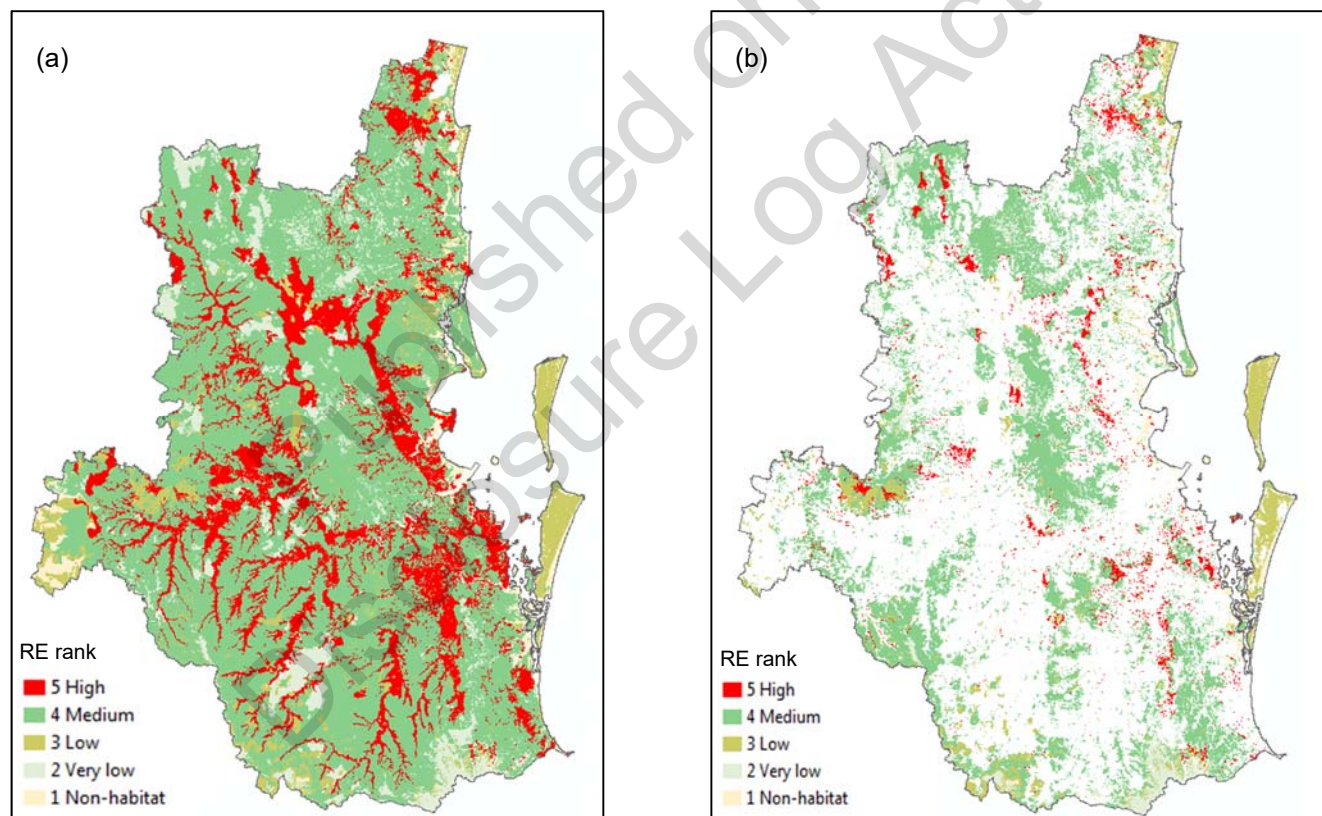


Figure 8: Regional ecosystem suitability classified into five classes. Pre-clearing (a) and remnant (b).

2.7.2 Species distribution modelling

Maxent modelling

The AUC in the final Maxent model (version 11.17) was 0.737 which is regarded as a good fit (Swets 1988). Models with an AUC > 0.7 are regarded as having good discriminatory power, although the AUC should not be used as a comparison between species or study areas (Anderson et al. 2011). In the final Maxent model, the

elevation (htele) measure was the largest single predictor of koala habitat suitability, contributing 40% to the model. The top eight measures contributed 88% to the model and consistently ranked higher than the remaining five measures in all model runs. The remaining five measures each contributed between 2% and 4% to the final model (Table 4).

Table 4: Contribution of the measures to the final Maxent model.

Measure	Measure code	Final model contribution
Elevation	htele	40.4
Seasonality	hctsv	12.3
Slope	htslo	9.5
Soil water	hswat	5.6
Ruggedness	htrug	5.4
Phosphorus	hspho	5.1
Temperature	hctem	5
GDE	hgpot	4.2
Moisture index	hcmil	3.7
NDVI	hIndv	2.6
Rainfall	hcapr	2.1
Nitrogen	hsnit	2
Cation exchange capacity	hscec	1.9

The modelled koala habitat suitability showed the highest ranked koala habitat was concentrated in the lowland regions of the study area extending along the alluvial flats from the coastal regions through the inland river valleys of the Brisbane, Bremer and Lockyer (Figure 9). Habitat suitability logistic values ranged from low suitability = 0.008 to high suitability = 0.964, mean suitability = 0.453 and standard deviation of suitability = 0.178.

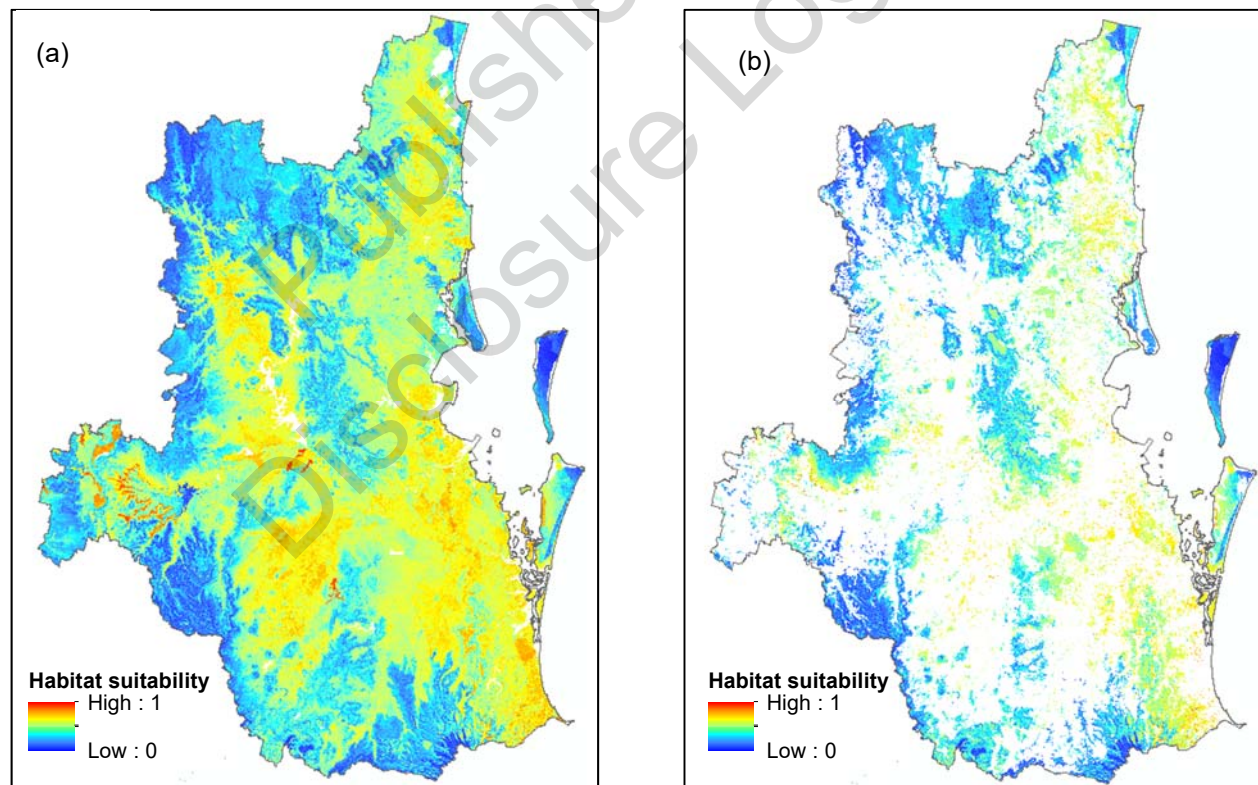


Figure 9: Maxent koala habitat suitability logistic values. Pre-clearing (a) and remnant (b).

The Maxent model for pre-clearing and remnant habitat, categorised into 3 classes (using the thresholds in Table 3), emphasises the strong relationship between high Maxent suitability and areas of low elevation as well as the

extensive clearing of high Maxent suitability areas (Figure 10). The confidence model indicates the confidence associated with the designation of high suitability, medium suitability and low suitability (non-habitat) (Figure 11). The confidence model (map) needs to be viewed in association with the three class Maxent model output (Figure 10). The confidence map shows high confidence in the Maxent model, particularly in the highest koala suitability areas (given a Maxent ranking of 3. High) and low suitability (non-habitat) areas such as Moreton Island.

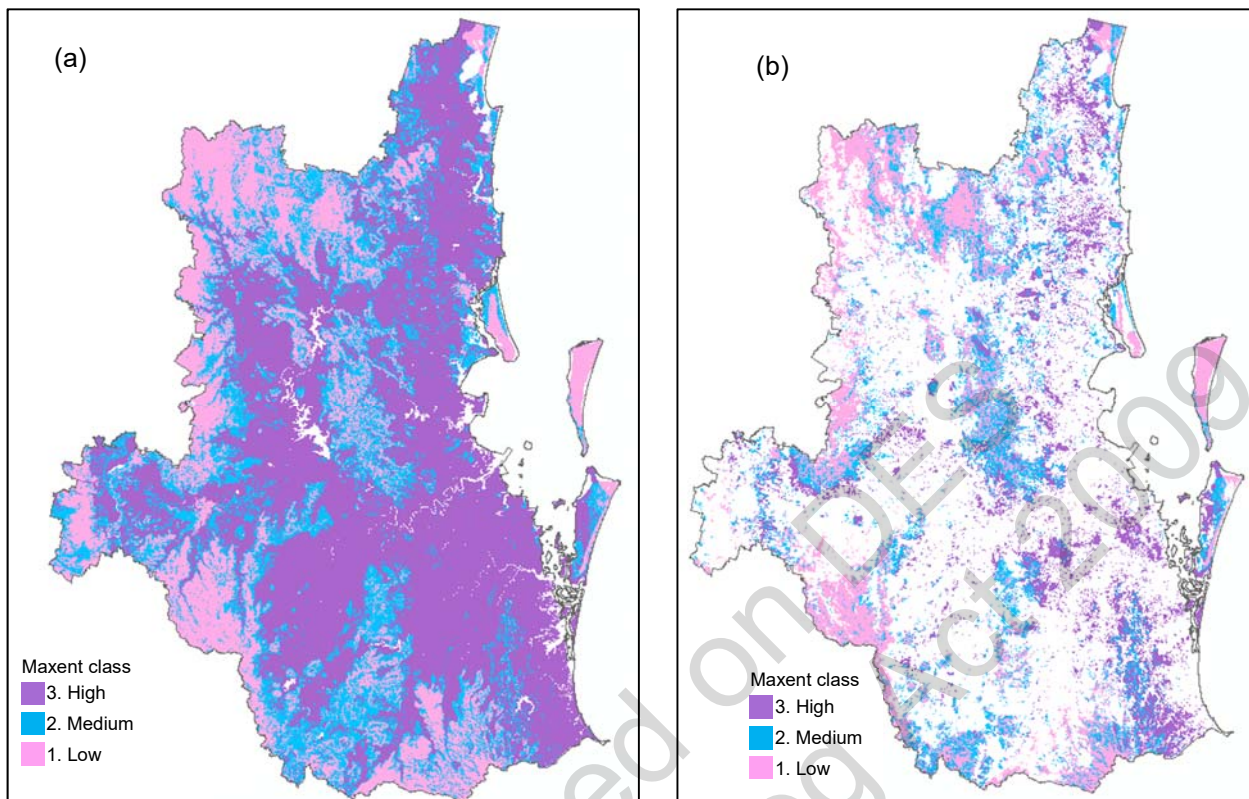


Figure 10: Maxent koala habitat suitability classified into three classes. Pre-clearing (a) and remnant (b).

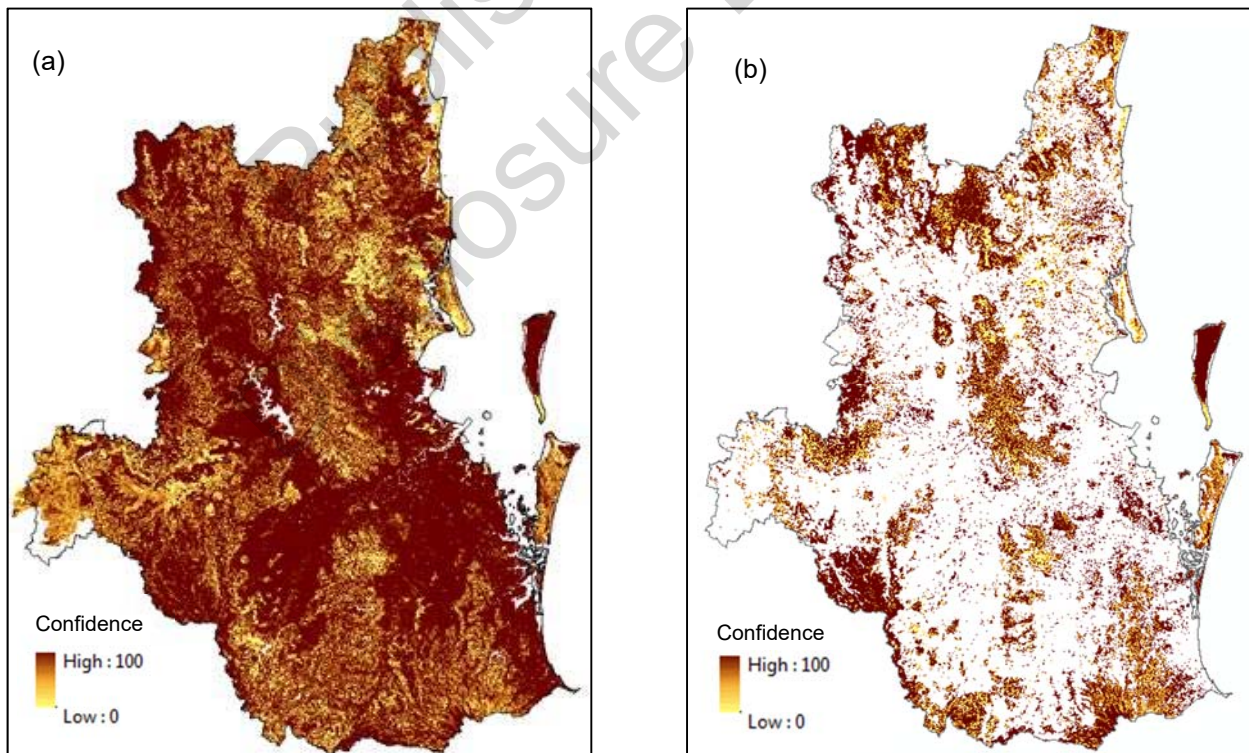


Figure 11: Confidence in Maxent model (version 11.17). Pre-clearing (a) and remnant (b).

The confidence map was obtained from 100 repetitions of the Maxent model using a random sample of koala records. Maxent model (version 11.17).

2.7.3 Koala habitat decision matrix

The habitat decision matrix areas for pre-clearing and remnant habitat are shown in Appendix 7.

2.7.4 Koala habitat map

Modelling the extent of pre-clearing habitat allowed a comparison to be made between current habitat extent and the composition and amount of koala habitat that was previously available (Table 5, Figure 12, Map 4).

Table 5: Extent of pre-clearing and current koala habitat within the study area*.

Habitat class	Pre-clearing area (ha)	Pre-clearing area (%)	Current area (ha)	Current area (%)	Change ⁶ (ha)	Change %
Remnant core	1,851,337	100%	518,757	28%	-1,332,580	-72%
Regrowth core	-	-	122,430	7%	-	-
Cleared core	-	-	1,210,150	65%	-	-
Total	1,851,337	100%	1,851,337	100%	-	-

* Due to rounding, numbers may not add up precisely to the totals provided in this table. Area calculated using MGA56.

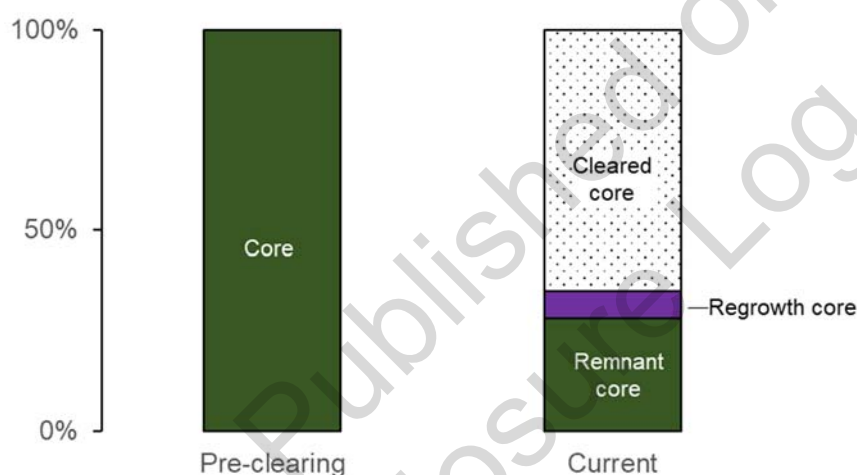
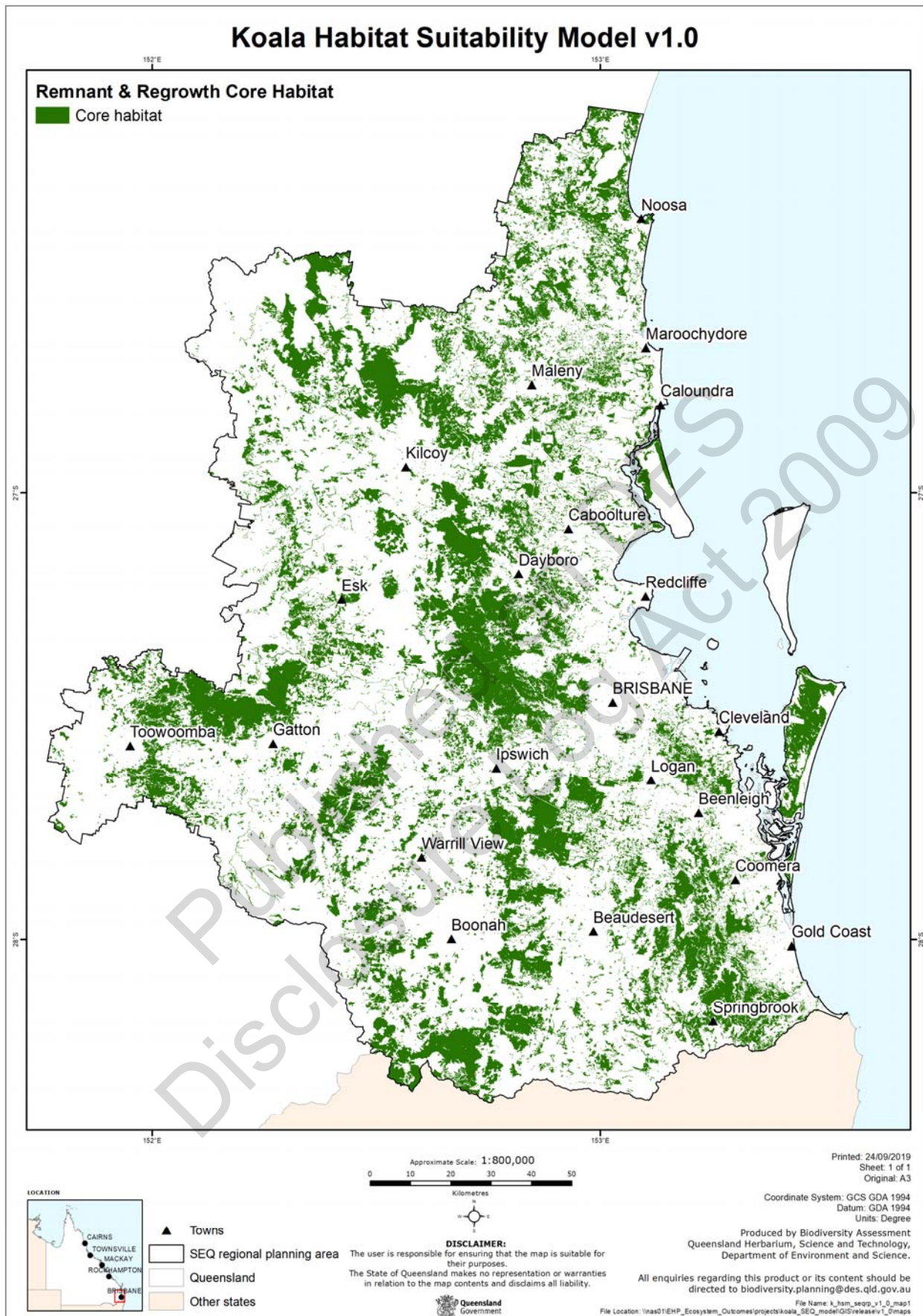


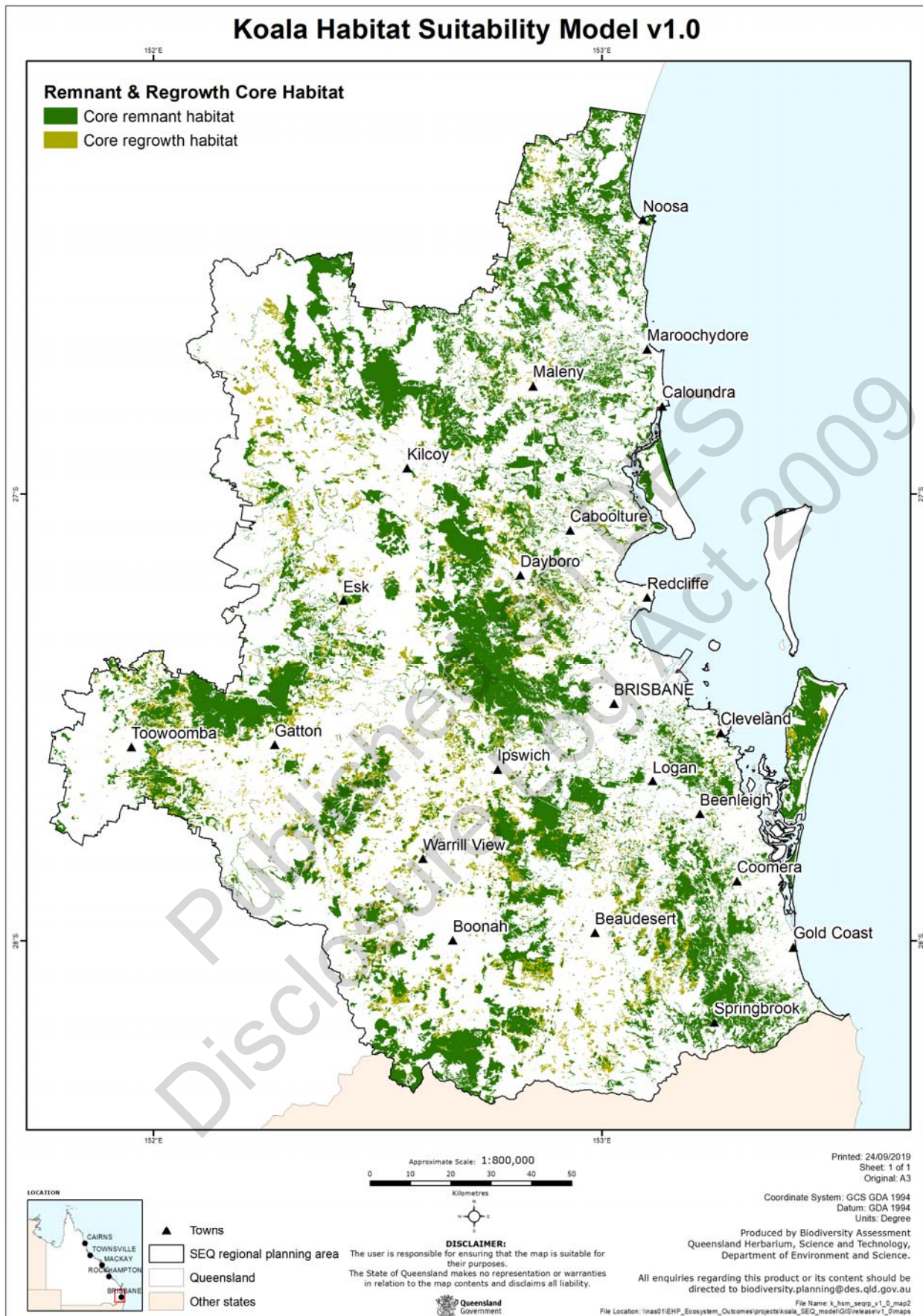
Figure 12: Comparative area of pre-clearing koala habitat and current koala habitat in SEQ.

The pre-clearing core habitat was distributed broadly across the study area (Map 4). The new koala habitat mapping identified that 28% of remnant core habitat is remaining (518,757ha) from a pre-clearing extent of 1,851,337ha (Map 1 and Table 5). This means there has been a loss of -1,332,580ha of core koala habitat and represents a 72% reduction from the pre-clearing extent. In addition to the remnant core habitat, an additional 7% of the study area has been identified as core regrowth habitat (122,430) (Map 1). Future improvements in the source data are likely to increase the proportion of regrowth identified. The extent of ranked koala habitat suitability is shown in Map 5 or pre-clearing and Map 3 for remnant and regrowth habitat.

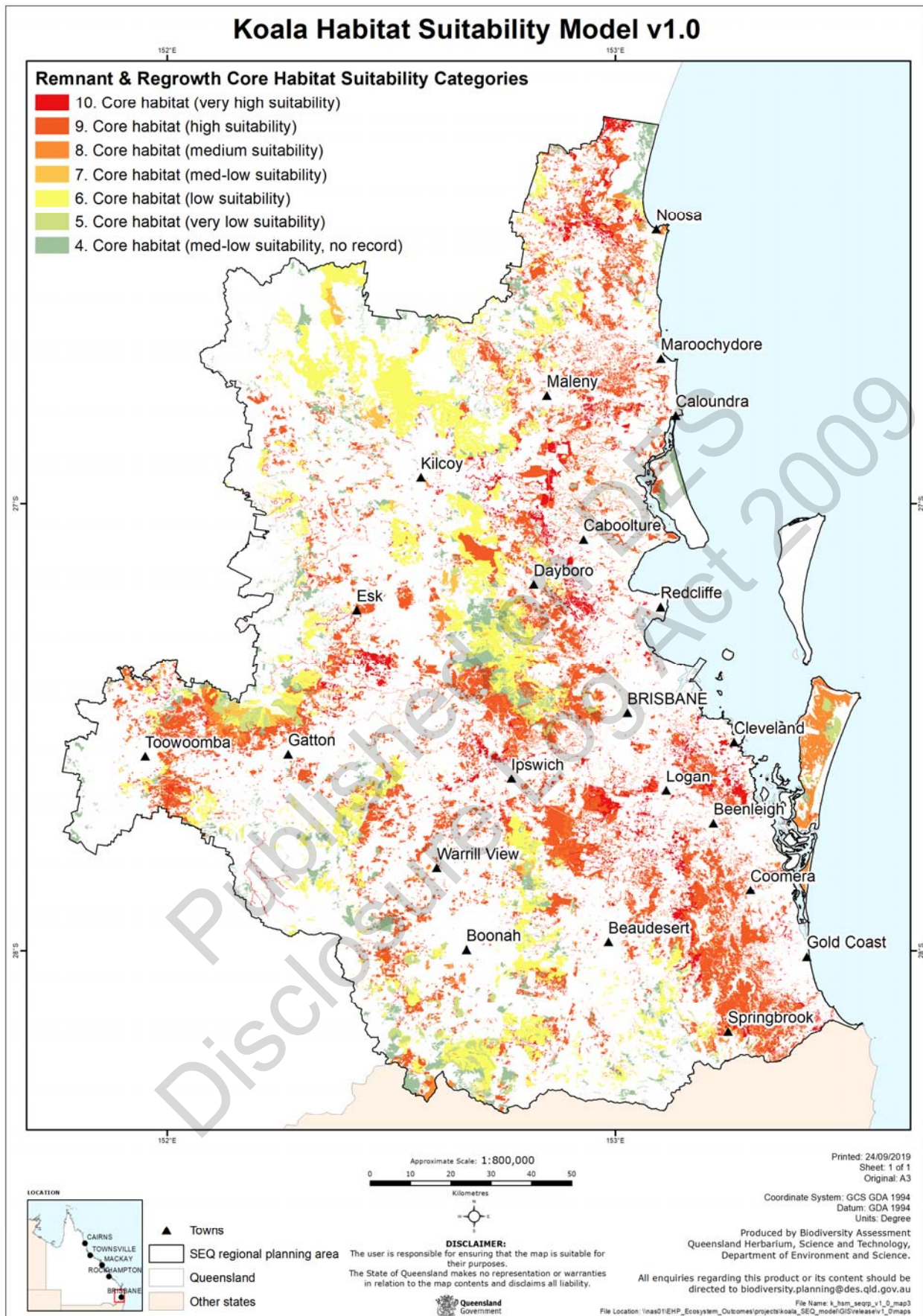
⁶ Difference between pre-clearing and current area.



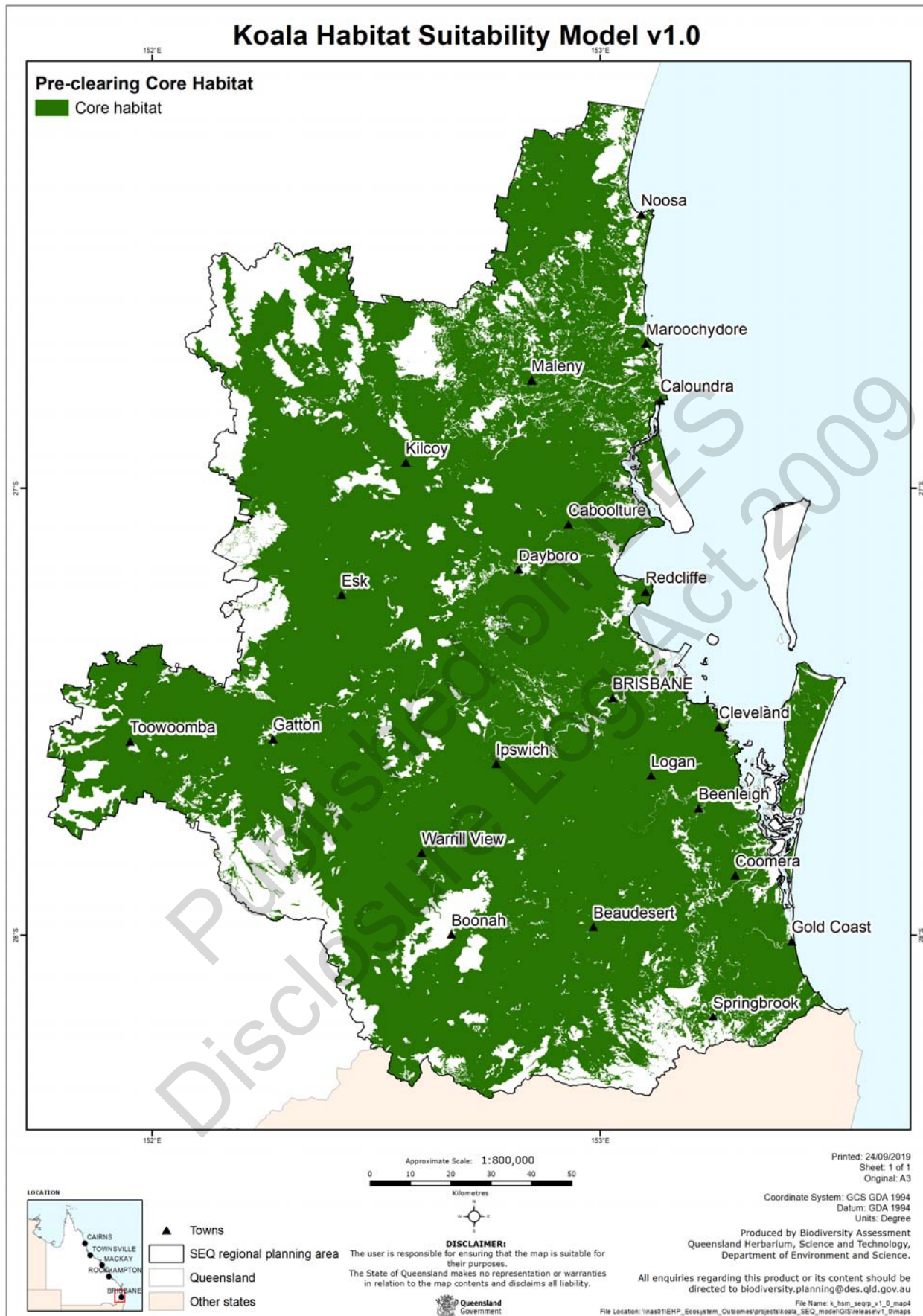
Map 1: Extent of core habitat (remnant and regrowth combined).



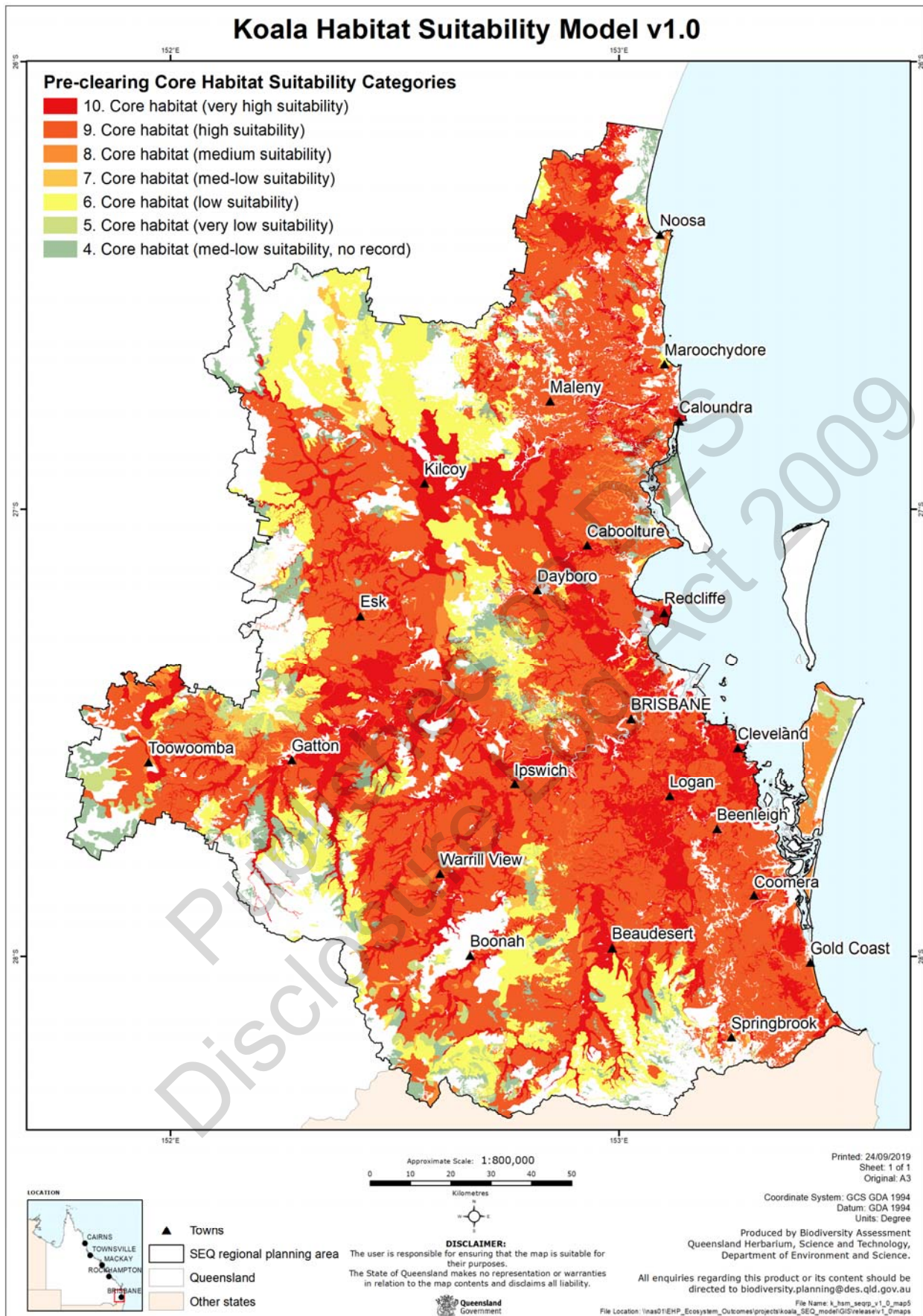
Map 2: Extent of remnant and regrowth core habitat.



Map 3: Extent of ranked habitat suitability categories for remnant and regrowth core habitat.



Map 4: Extent of pre-clearing core koala habitat.



Map 5: Extent of ranked habitat suitability categories for pre-clearing core habitat.

2.7.5 Validation of koala habitat mapping

2.7.5.1 Map accuracy: Point validation

Overall map accuracy assessed using point validation from independent koala records supplied by supplementary sources showed a 95% agreement (251/264) with 251 of the 264 field records of koala presence falling in areas mapped as koala habitat (Table 6).

Table 6: Map accuracy using independent koala records.

Source	Number of koala records falling in areas mapped as habitat (n)	Total number of koala records (n)	Agreement (%)
GHD	88	96	92%
McAlpine	110	114	96%
Rhodes	53	54	98%
Total	251	264	95%

2.7.5.2 Map accuracy: Stratified random sampling

Overall map accuracy for identifying tree cover was 86% (see Table 7). The accuracy of identifying remnant cover was 100% and non-remnant cover was 71%. Combined accuracy for remnant and regrowth cover was 89%. The 100% accuracy in identifying remnant cover is attributed to the Queensland Herbarium's expertise in state-wide, comprehensive vegetation mapping.

Table 7: Map accuracy assessment using stratified random sampling.

Cover	Remnant and non-remnant
Remnant	100% (100/100)
Non-remnant	71% (51/70)
Total	89% (151/170)

Values in brackets represent sample size

3 Modelling priority areas for koala conservation

The Koala Expert Panel final report (Rhodes et al. 2017) recommended a more strategic approach to conserving koalas in SEQ, including identifying a network of priority areas in the landscape for koala habitat conservation. Identification of these priority areas included the mapping of threats, constraints, opportunities, and resilience measures, and the use of spatial prioritisation modelling to identify the optimum areas for koala habitat conservation to enhance the long-term viability of koalas within the southern SEQ bioregion. This section focuses on the methods used to identify and select the priority areas.

Spatial data sets that represent direct measures or proxies of threats such as urban development, land clearing, dog attacks, vehicle collisions, fire management, climate change, disease, and reductions in genetic diversity were included in the analyses (Rhodes et al. 2017). Opportunities and resilience measures, such as existing conservation areas and climate refugia, were also considered for their potential to help leverage conservation actions to support viable koala populations.

The spatial modelling and planning for koalas (SMPK) project developed a three part approach to help guide the identification of priority areas for koala conservation in southern SEQ which included:

1. Development of a habitat model in which vegetation, including pre-clearing and remnant regional ecosystems (REs), and non-remnant high value regrowth layers, were ranked based on their suitability for koala habitat (shown in section 2). This model was used to provide the target features to be conserved in prioritisation modelling.
2. Mapping of key threats, constraints and opportunities that may either help or hinder koala survival in a particular patch of habitat. Spatial data sets that represented direct measures or proxies of threats such as urban development, land clearing, dog attacks, vehicle collisions, fire management, climate change, disease, and reductions in genetic diversity (Lee et al. 2010) were included in the analyses (Rhodes et al. 2017). Opportunities and resilience measures, such as existing conservation areas and climate refugia, were also considered for their potential to help leverage conservation actions to support viable koala populations. These formed an ecological cost layer for prioritisation modelling.
3. Identification of priority areas for koala habitat conservation, using prioritisation software. Marxan was used for prioritisation because it is the most widely used systematic conservation planning software in the world. It allows policy makers and planners to explore different management options and scenarios to design effective conservation areas in mixed-use landscapes (Ardron, Possingham & Klein 2010). The software uses a reserve selection algorithm that optimises the spatial selection of areas based on their contribution to meeting one or more ecological targets at a minimum cost.

3.1 Approach

3.1.1 Threats and constraints

Threats are considered direct and immediate factors that could do physical harm to koalas, while constraints are factors that can limit an area's ability to support habitat. A conceptual diagram of threats and constraints is shown in Figure 13.

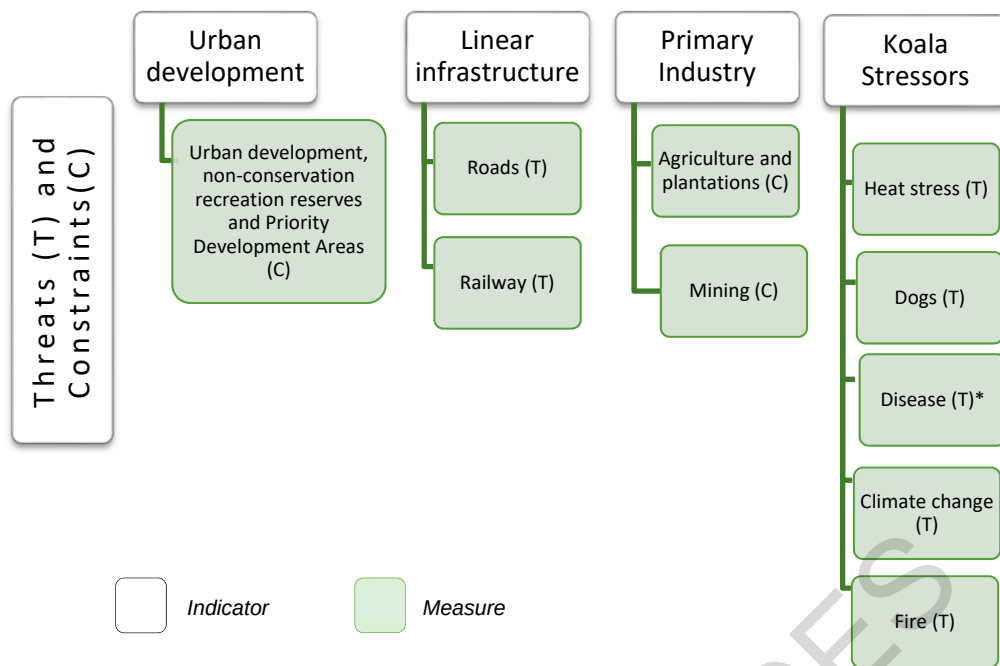


Figure 13: Threats (T) and constraints (C) indicators and measures.

* Not implemented due to absence of spatial data representing koala disease threat

3.1.2 Opportunities and resilience

Opportunities and resilience represent areas that in combination achieve conservation outcomes by increasing the likelihood of long-term persistence of koalas. Opportunities include existing reserves or areas managed with a conservation intent that offer longer term retention of habitat where koalas can persist. Refugia include areas where koalas can shelter when their wider geographic distribution becomes uninhabitable from the longer-term impacts of climate change and shorter term impacts of bushfires, clearing or extreme weather events such as heatwaves. A conceptual diagram of opportunities and resilience is shown in Figure 14.

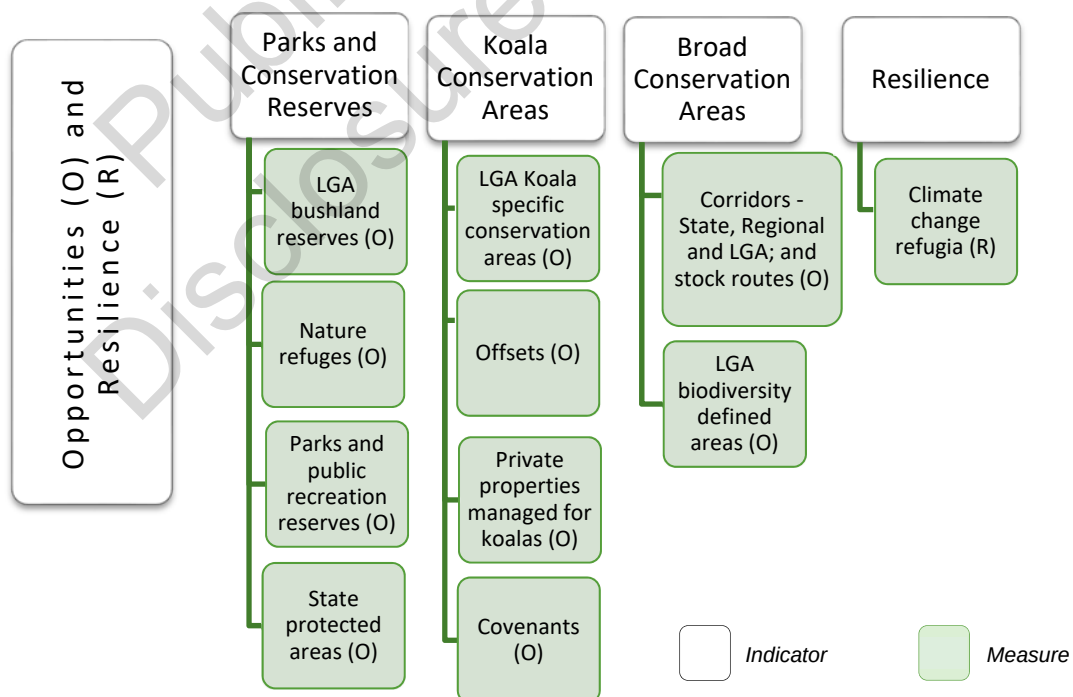


Figure 14: Opportunities (O) and resilience (R) indicators and measures.

3.2 Marxan modelling

A variety of scenarios were explored with Marxan, using different combinations of conservation feature targets and ecological costs, based on threats, constraints and opportunities. Here, we focus on the scenario chosen by DES to identify priority areas for koala conservation (see section 4). This used a subset of key variables selected by the Koala Policy and Oversight (KPO) team, who were the end users of the priority area modelling.

3.2.1 Marxan inputs

The essential inputs for Marxan are conservation features and costs, which are allocated to a set of spatial planning units. Marxan uses a technique called simulated annealing to find near-optimal solutions that meet the conservation target with the minimum number of spatial units and the lowest cost. The simulated annealing algorithm compares spatial units and progressively discards those that do not lower the overall cost while meeting the targets until close-to-optimal solutions are reached. The overall workflow is shown in Appendix 8.

3.2.2 Planning units

To identify the priority areas recommended by the KEP report, the SEQ planning region was divided into 100 ha hexagons (total of 23,929 planning units). The choice of hexagon size was a balance between providing enough detail for meaningful planning and keeping the total number of units at a reasonable level for subsequent spatial analysis.

3.2.3 Conservation features

The conservation features in the chosen scenario were ~230,000 ha of core koala habitat from the koala habitat model developed by the SMPK project. Table 8 shows the target conservation features and Figure 15 shows the distribution of core and non-core habitat conservation features. Appendix 9 shows details of the habitat suitability decision matrix and habitat mapping used to generate the target conservation features.

Table 8: Conservation targets and habitat types used in Marxan conservation modelling scenario*.

Category	Description	Remnant and non-remnant (ha)	Percentage remaining (%)	Marxan targets (ha)	Marxan targets (%)	Penalty factor used in Marxan
10	Very high quality koala habitat with or without sightings	98,025	24.4	63,716	65	20
9	High quality koala habitat with or without sightings	378,307	38.9	94,576	25	10
8	Medium-high quality koala habitat with or without sightings	38,146	66.1	9,536	25	10
7	High quality koala habitat with sightings	11,882	57.6	4,753	40	10
6	Medium-high quality koala habitat with sightings	202,099	74.8	40,419	20	10
5	Very low suitability koala habitat with sightings	20,650	63.1	2,065	10	10
4	Very low suitability koala habitat without sightings	87,725	90.7	13,158	15	10
Totals		836,834	45.2	228,223		

* Marxan conservation scenario 112, run 3. Based on draft koala habitat model. Inputs: remnant habitat, high value regrowth (HVR), regrowth from the offsets program (EHP 2015) and scattered trees koala habitat. Core habitat (suitability categories 4 – 10).

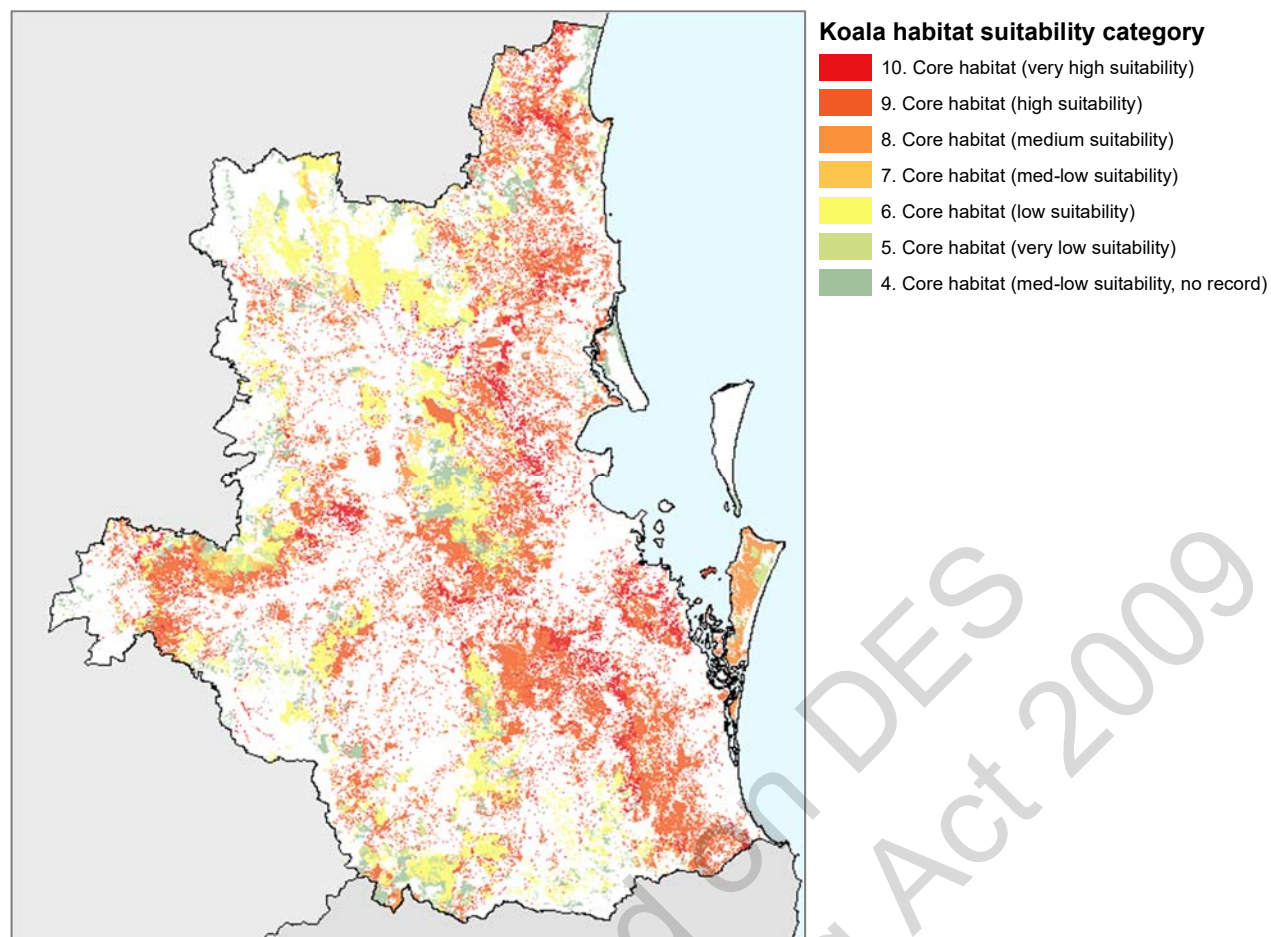


Figure 15: Potential habitat conservation features available for selection.

3.2.4 Ecological cost layer

The cost layer in Marxan can either be monetary, e.g. land value or lost economic opportunity, or non-monetary such as ecological threats from changes in land and resource use (Rebello et al. 2011; Lötter et al. 2010). The cost layer used in Marxan to identify priority areas for koala habitat conservation was an ecological cost, or a trade-off between threats/constraints and opportunities/resilience (TCOR). Threats are direct and immediate factors that could do physical harm to koalas, such as dog attacks and heat stress, while constraints are factors that could limit an area's ability to support appropriate habitat such as urban development or cropping. Opportunities included existing reserves or areas managed with a conservation intent that offer longer term retention of core habitat where koalas can persist. Resilience identified areas where climate change was less likely to affect koala habitat, from the Maxent model. The ecological cost in Marxan was a single value, comprising different combinations of TCOR elements. Each TCOR variable was normalised to a similar scale with a range of 0 – 1. In the chosen scenario, variables were ranked and weighted, with the weights summing to 1. This is a common method of combining multiple factors with comparable scores (Lötter et al. 2010). Table 9 shows the range of threats, constraints and opportunities that were considered in the chosen scenario. Figure 16 illustrates the spatial distribution of the ecological costs. Maps of the individual costs for the chosen scenario are shown in Appendix 10.

Table 9: Threats (T), constraints (C) and opportunities (O), ranking and weighting used in the chosen scenario.

Threats or Constraints	Ranking	Weighting
• Heat stress (T)	Medium	0.75
• Climate change (T)	Low	0.5
• Urban development (C)	High	1.0
• Extractive industry (C)	Low	0.5
Opportunities		
• Conservation & environmental management (O) [#]	High	1.0
• Current bushland habitat in KADA and PKADA areas** - all classes (high, medium, low bushland and high and medium rehabilitation) [#]	High	0.5*
• Habitat adjacent to protected areas (within 5 km)	Low	0.5

[#] Scores for these two opportunities were reversed, so that a high opportunity reflected a low cost, since Marxan preferentially chooses lower cost planning units.

* Current bushland opportunities were weighted at 0.5, although they were ranked as highly important, because they covered very limited parts of the region.

** Koala Assessable Development Areas (KADA) and Priority KADA (PKADA)

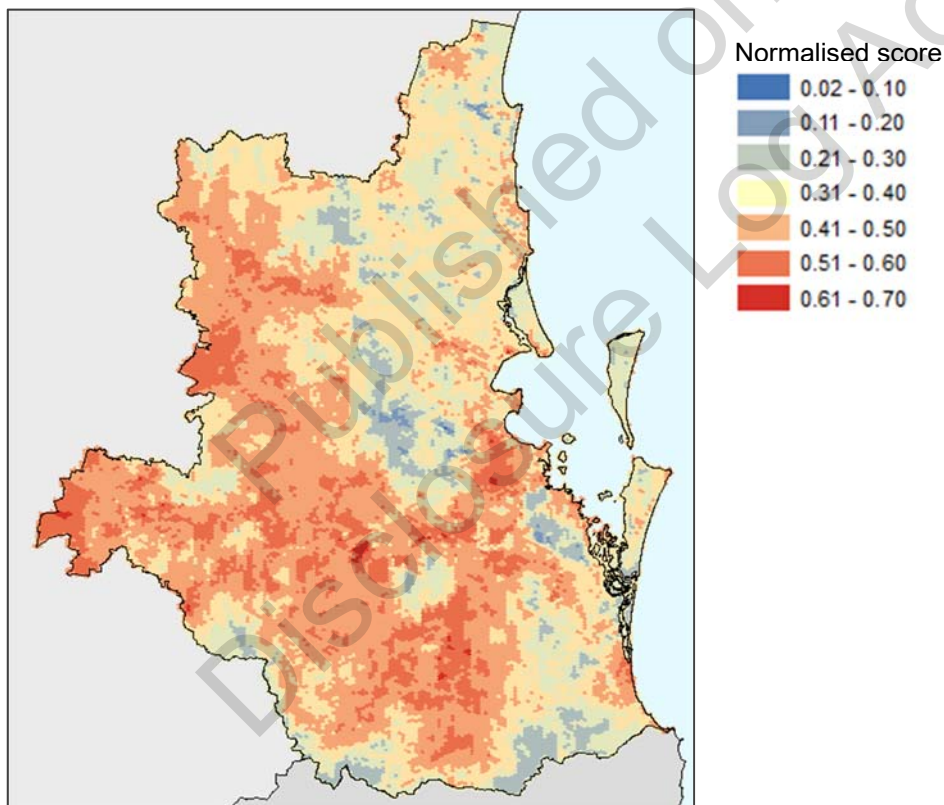


Figure 16: Ecological cost map for the chosen scenario.

Shows weighted threats, constraints and opportunities layer (see Table 9 for details). Areas with a high ecological cost are red and low cost areas are blue.

3.2.5 Marxan outputs

The outputs shown below are based on the selection frequency over 100 runs, with 10 million iterations for annealing and a boundary length modifier of 10 (Figure 17). This gave a solution that was moderately clumped but still provided enough choice for stakeholders to tailor on-ground conservation outcomes to the optimisation results. The other input parameter factors were kept as standard. For examples of how the conservation features and ecological costs were calculated, and the Marxan selection frequencies see Appendix 11.

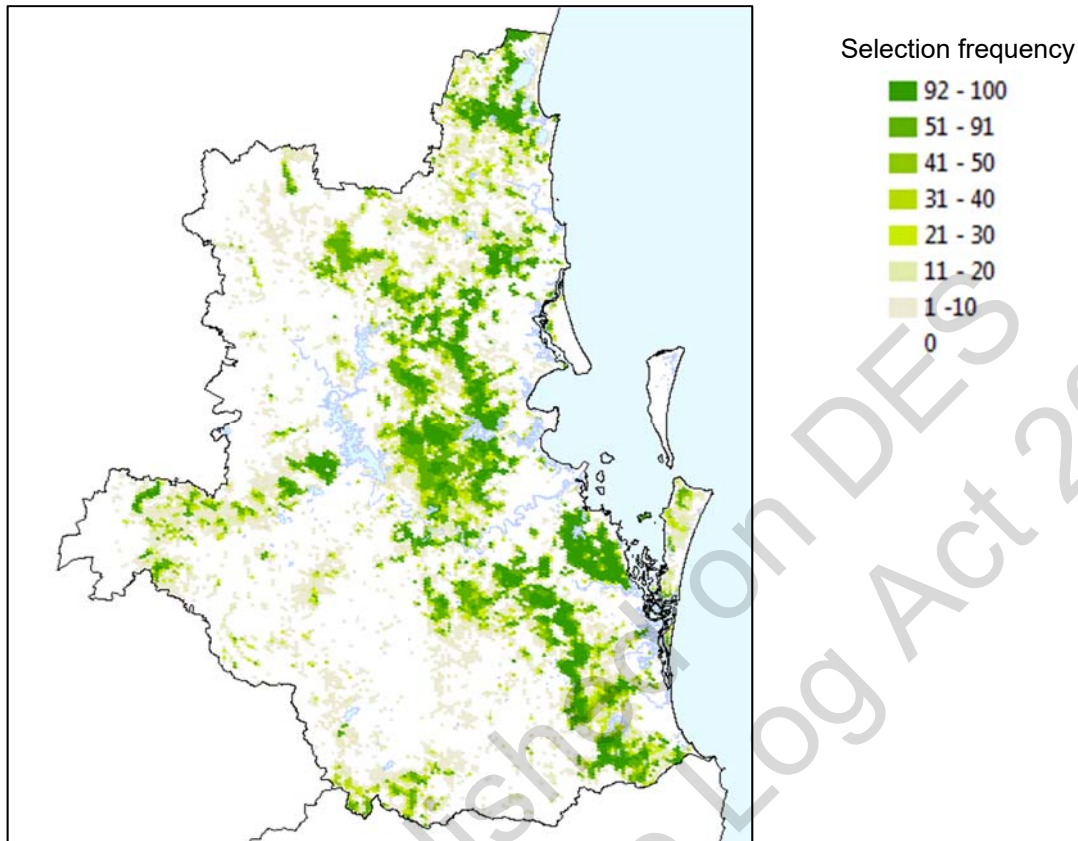


Figure 17: Selection frequency for Marxan prioritisation based on chosen scenario.

4 Koala Priority Areas (KPA)

4.1 KPA boundary development

The conservation of koalas depends on conserving areas of habitat that are large enough and/or well-connected enough to maintain viable populations of hundreds or thousands of koalas (Rhodes et al., 2017). The Koala Expert Panel (2017, p. 8) recommended protecting priority areas of “100,000s of hectares” of koala habitat. The Department of Environment and Science aimed to identify a network of priority areas in the landscape for koala habitat conservation where stronger regulatory control over habitat clearing could exist. The Marxan prioritisation output was used by the KPO team to develop these koala priority areas (KPAs).

4.2 Methodology

The method used interpolation to convert the Marxan model (run 112, scenario 3) from integer cells to a continuous surface and then summarised each cadastral parcel by the interpolated Marxan values found within.

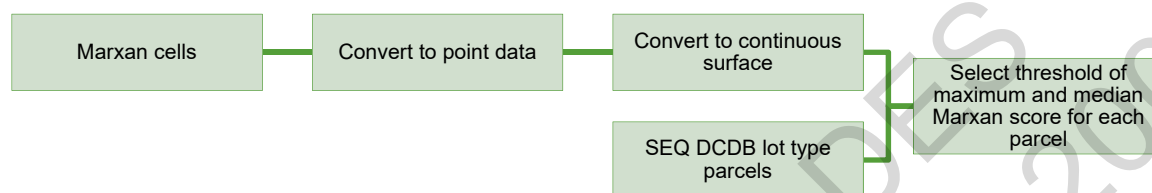


Figure 18: Flowchart of process to develop KPA boundaries.

The selection frequencies in Marxan outputs are a measure of how often a particular cell contributes to meeting the target—in this case, core remnant and regrowth koala habitat. Therefore, a cell with a selection frequency of 50 was chosen 50 times in our 100 run scenario (meaning the cell was chosen 50% of the time). The KPO team used a selection frequency cut off of 40 to identify the initial KPA boundaries. The Marxan hexagons were converted into points and a TIN surface was used to interpolate the points into a continuous surface. The TIN surface was converted to the 10 x 10 m grid, and zonal statistics were used to summarise the grid values within each cadastral parcel. Cadastral boundaries for SEQ were taken from the Queensland DCDB spatial data. The maximum score threshold (the highest raster cell value in each parcel) was used to identify whether the property should be inside or outside the KPA area. Parcels with selection frequencies of 40-100 were then aggregated and snapped to the cadastral using a fully automated procedure to produce the first draft (March 2019) KPA boundaries (Figure 19).

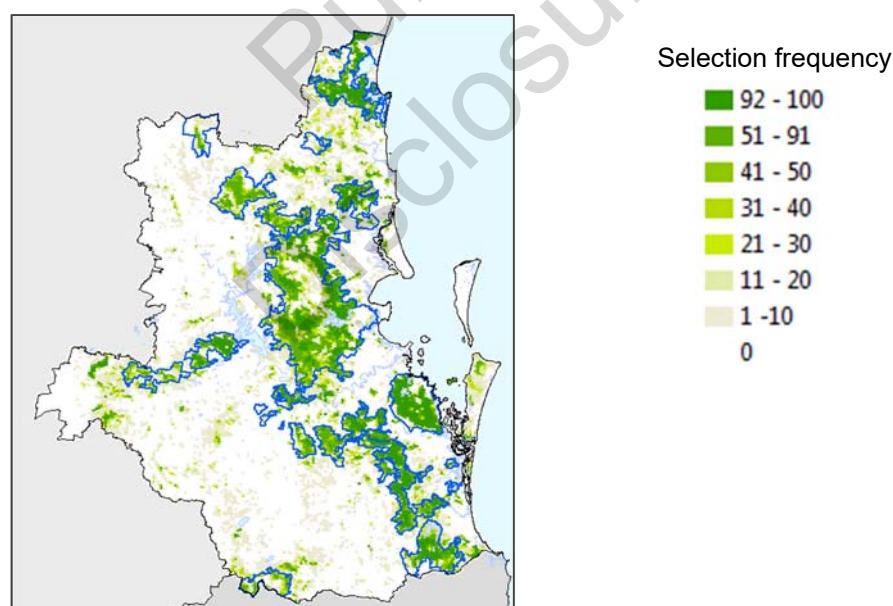


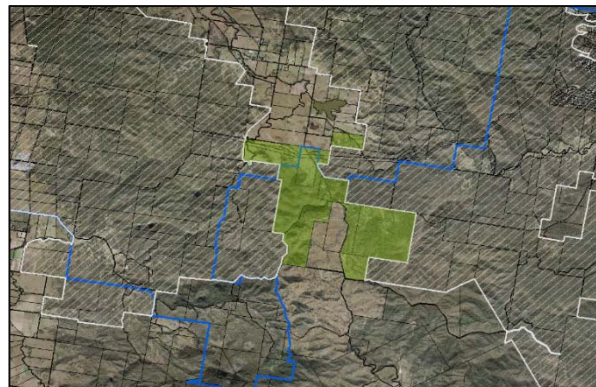
Figure 19: Marxan selection frequencies and first pass of Koala Priority Areas (KPAs) (outlined in blue).

4.3 KPA boundary refinement rules

The initial KPA boundaries were adjusted using a set of decision rules to improve connectivity, address anomalies in the KPA boundaries and take into account feedback from local governments (see Map 6).

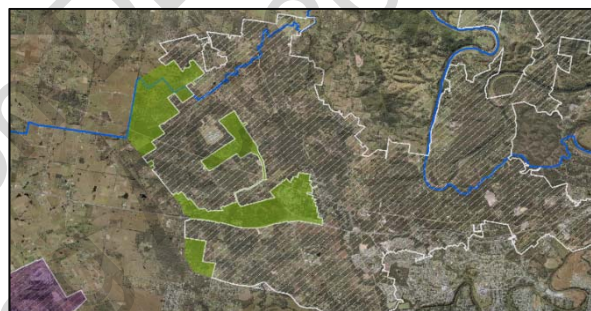
1. Link together KPAs where they were connected by suitable koala habitat:

- KPAs were connected along cadastral boundaries where contiguous suitable koala habitat was present or where KPAs are separated by small slivers of land not within KPAs.



2. Adjust anomalous KPA boundaries to achieve boundary smoothing:

- Where KPA boundaries were coarse (positioned ambiguously through communities or land uses, or created bisections of koala habitat), boundaries were adjusted and aligned to clear and recognisable features (such as rivers, roads, protected area boundaries).
- Care was taken to not exclude smaller patches of important koala habitat in the urban landscape during this process.
- This rule also applies to areas that were selected to delete from the KPA boundary in cases where there was geographical boundaries separating habitat, a lack of mapped habitat, extensive non-native plantation uses and areas that were not suitable for koalas (zoning, lack of habitat).

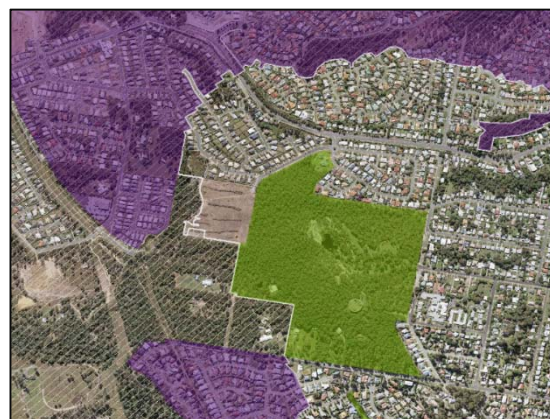


3. Avoid bisecting koala habitat:

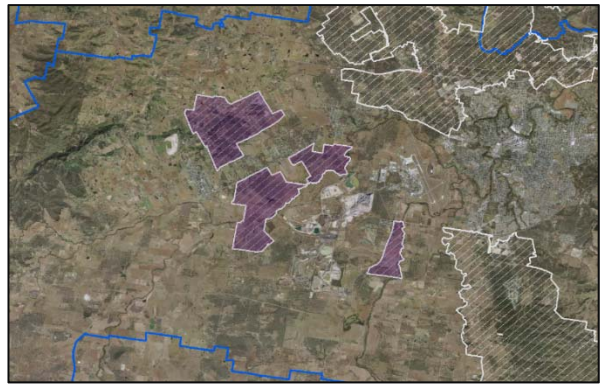
- KPA areas were adjusted to incorporate areas of connected habitat where the boundary was bisecting this habitat. This can involve retracting or expanding adjacent areas of connected koala habitat where the Marxan output attributes a similar cost.

4. Adjust small cadastral errors or removal of isolated KPA areas:

- Removal of KPAs where isolated protected areas were selected and were not contributing to larger, connected areas of suitable koala habitat.
- Small boundary errors associated with computer generated outputs snapped to the cadastral boundaries were adjusted with guidance from the Marxan scenario, koala habitat and land use data.



5. Koala Assessable Development Areas (KADAs) were retained within KPA areas:
- An exception was where KADAs were removed if they were considered small and/or isolated areas that did not contribute towards significant areas of connected suitable koala habitat, e.g. in the Ipswich LGA.



6. Priority Koala Assessable Development Areas (PKADAs) were retained within KPA areas.



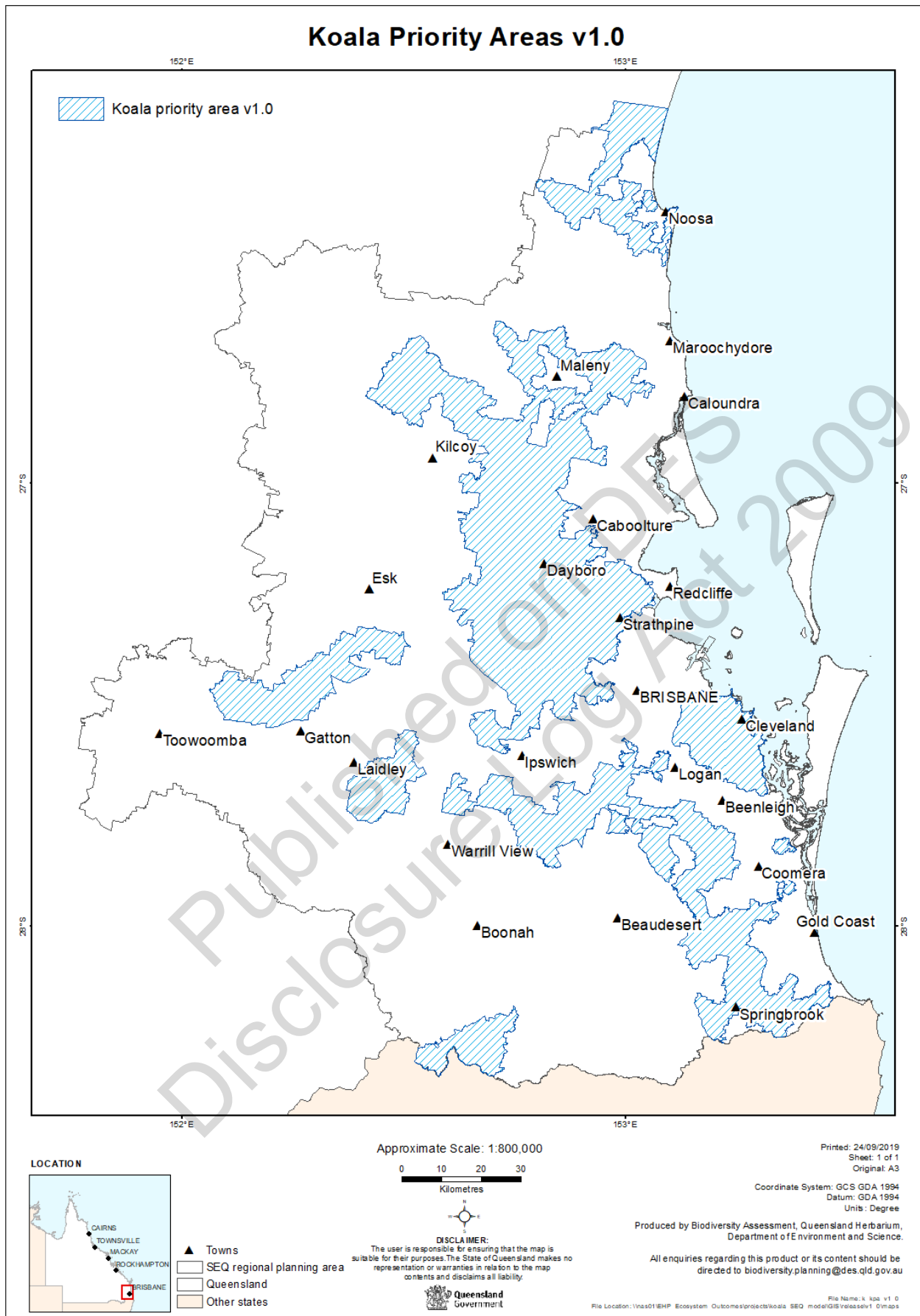
7. Extension of KPAs to include areas that **local governments requested** where they are investing ongoing koala conservation initiatives that contribute towards koala conservation outcomes:
- This was considered to support the Koala Expert Panel's recommendation to direct coordinated conservation efforts across levels of government into identified priority areas.
 - Councils exposed areas where local koala populations are maintained through koala conservation initiatives (monitoring, threat abatement, restoration, citizen science etc.).
 - Areas suggested by council were considered for inclusion as KPAs using sightings data, local government policy and regulations (corridors, precincts), conservation program areas (LFW, Covenants, local reserve networks).
 - Areas suggested by council were considered for inclusion as KPAs also by their proximity to existing KPAs (where the patch size is small), presence and connectivity of suitable koala habitat using the v1.0 koala habitat mapping and the Marxan and TCOR modelling for the KPAs.
 - Priority Development Areas were removed from KPAs for local governments that requested this.

Rules 1 to 5 were also guided by:

- Available koala sightings
- Marxan ecological cost data
- Land zones from local government mapping online resources or advice provided from local government consultation
- Koala habitat suitability mapping
- Local government conservation areas if provided during the local government consultation process.

4.4 Results

The area of KPA was 577,174ha. The spatial distribution of KPA areas is shown in Map 6.



Map 6: Map of Koala Priority Areas (KPAs).

5 Koala habitat restoration areas (KHRA)

5.1 Approach

Koala habitat restoration area mapping identifies cleared habitat where potential restoration activities for koalas are preferred to support remnant and regrowth koala habitat. The areas are located both inside and outside the KPA to acknowledge that restoration of degraded habitat occurs across SEQ. Koala habitat restoration areas are intended to be indicative and may be used to inform planning decisions, offsets policy and the koala program delivery decisions.

Restoration areas relied on a separate Marxan analysis to the KPA Marxan analysis ('restoration' scenarios). The purpose was to identify viable areas for koala habitat restoration using a target and considering a range of threats, constraints and opportunities for restoration. Cleared habitat in SEQ that previously contained very highly and highly suitable koala habitat was used in the Marxan restoration analysis (Figure 20 showing pre-clear) which determined a target scenario of 90,000 ha (~6%) of habitat being restored (Table 10). A threats, opportunities and constraints layer (Marxan ecological cost) was applied to the scenario (Figure 22). A final scenario was produced which identified the most viable areas for restoration (Figure 23).

Like the initial KPA analysis, the final Marxan scenario base unit was 100ha hexagons which was too broad for realistic interpretation. Therefore the mapping was re-applied to mapped cleared habitat which formerly contained highly suitable habitat. These were mapped only where Marxan identified suitable restoration areas.

After feedback from local government, further refinement removed areas in the mapping where restoration was considered unsuitable in certain planning scheme zones or areas. However, relevant areas were retained where an environmental corridor (or biodiversity area) was present.

Table 10: Conservation targets and habitat types used in Marxan restoration modelling scenario.

Scenario	Habitat type	Marxan target (ha)
Koala habitat restoration targeted mapping	Cleared habitat on former very high and high suitability regional ecosystems under matrix rules R351, R350, R341 and R340.	90,000

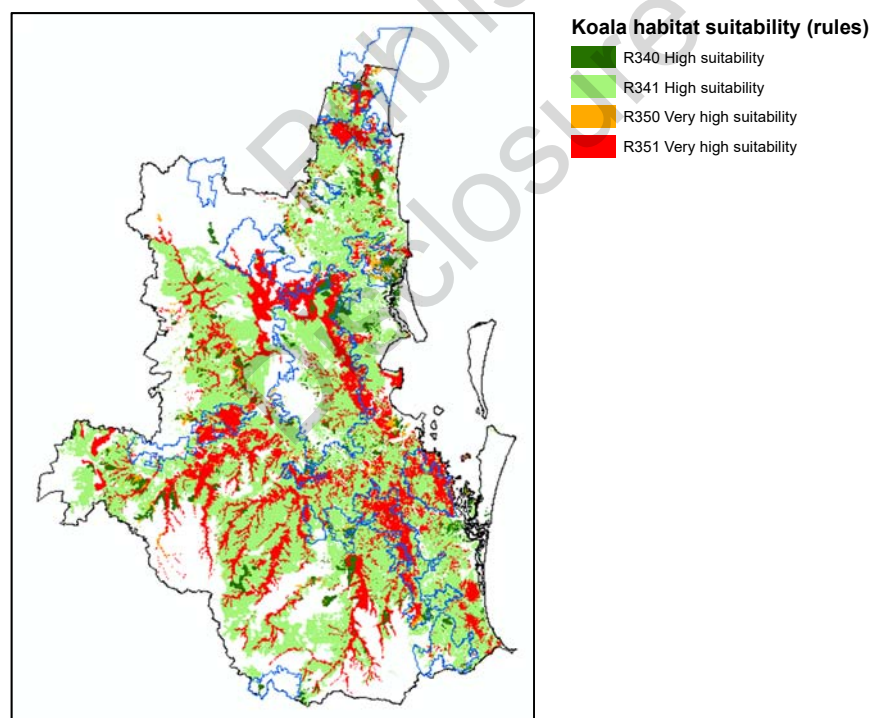


Figure 20: Pre-clearing distribution of high and very high suitability koala habitat.

The threats, constraints, opportunities and resilience (TCOR) layers were weighted and normalised, consequently, each layer had different relative importance. To encourage selection, the scores for all opportunity variables (except distance to frequently selected hexagons for protection) were reversed so high opportunities were given a low score because Marxan preferentially picks cells with lower costs. The ecological cost layer was made up from ten weighted threats, constraints, opportunities and resilience layers (Table 11). Results are shown in Figure 21.

Table 11: Variables and rankings for the ecological cost layer in the Koala Habitat Restoration scenario.

Available Threats or Constraints	Ranking*
• Roads (T)	Medium
• Heat stress (T)	Medium
• Climate change (T)	Low
• Urban development (C)	High
• Extractive industry (modified) (C)	High
Opportunity	
• Conservation & Environmental management (O)	High
• Draft KPA mapping scenarios	High
• Current bushland habitat in PKADA and KADA areas (high, medium, low bushland and high and medium rehabilitation) (O)	Medium
• Areas with cleared high value habitat within 1-5 km of Marxan frequently selected areas for habitat protection (O)	High
Resilience	
• Refugia resilient to climate change (R)	Medium

* These equate to a weighting of 100% for high, 75% for medium and 50% for low ranking.

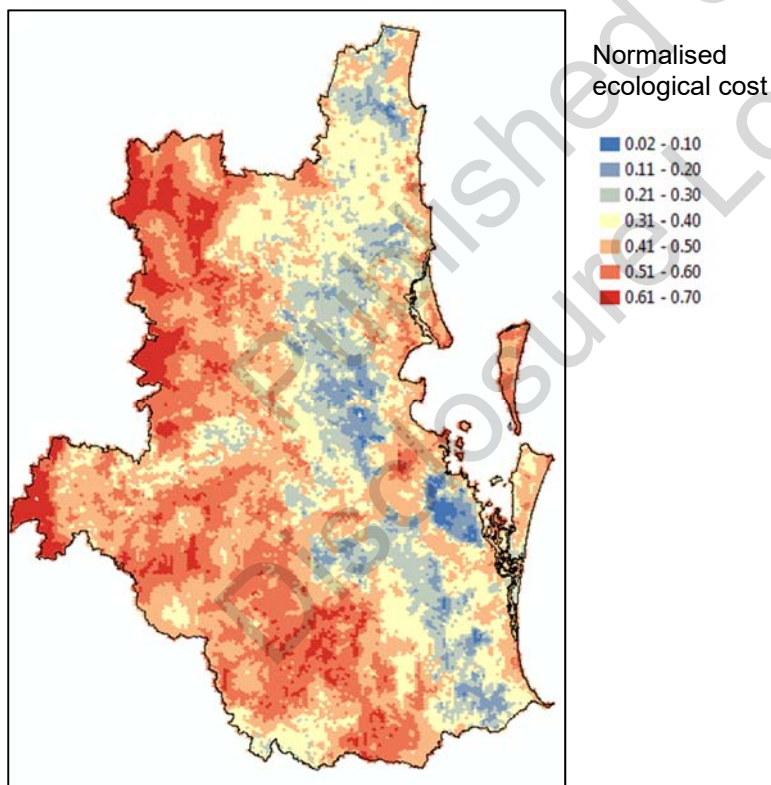


Figure 21: Marxan ecological cost input layer.

After local government feedback, a further refinement process removed areas that were potentially unsuitable for koala restoration. The refinement removed areas where zoning was considered unsuitable (such as urban zoning including centre, residential, industry and other zones associated with urban infrastructure). However, areas were retained where a state or local environment corridor occurs over the zoning (or suitable biodiversity area if an environment corridor was not available). Areas of existing koala restoration activities were also retained (where available) if they occurred in these areas. Consideration was given to remove intensive use areas in rural zones but

was not applied in this version. The refinement used currently available planning scheme zoning and precinct zoning and applied to standardised zoning under Schedule 2 of the Planning Regulation 2017. The refinement also sourced regional and local government biodiversity data either directly from local government request or through open data platforms.

Potential restoration areas based on a target of 90,000 ha of cleared very high and high suitability koala habitat are shown in Figure 22 below.

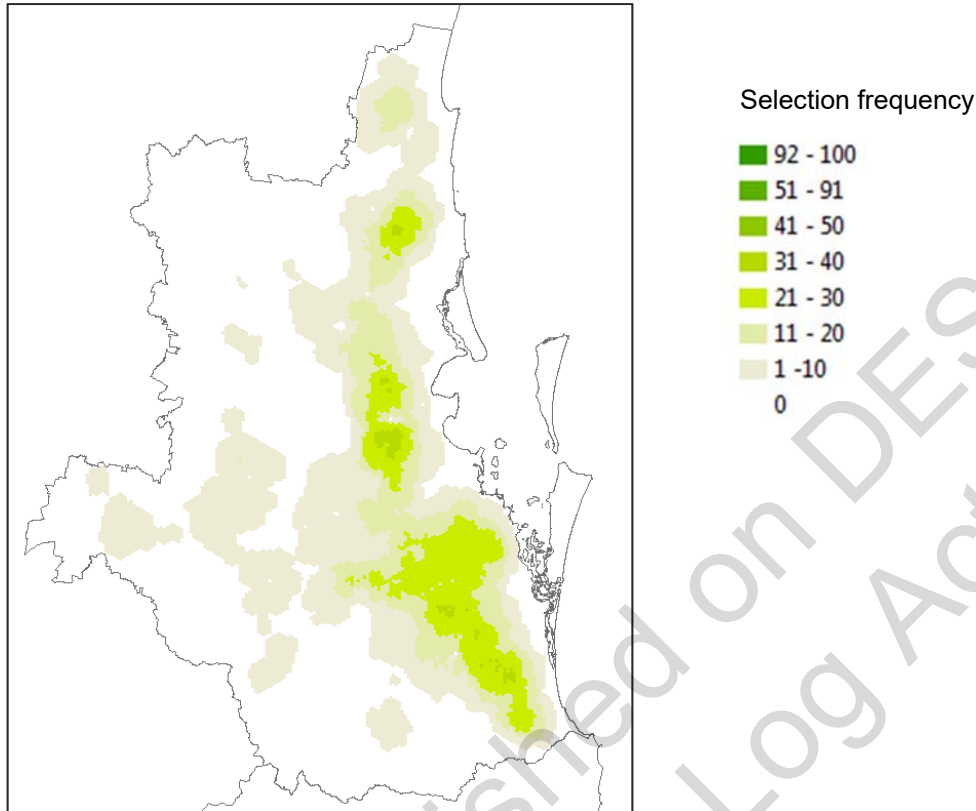
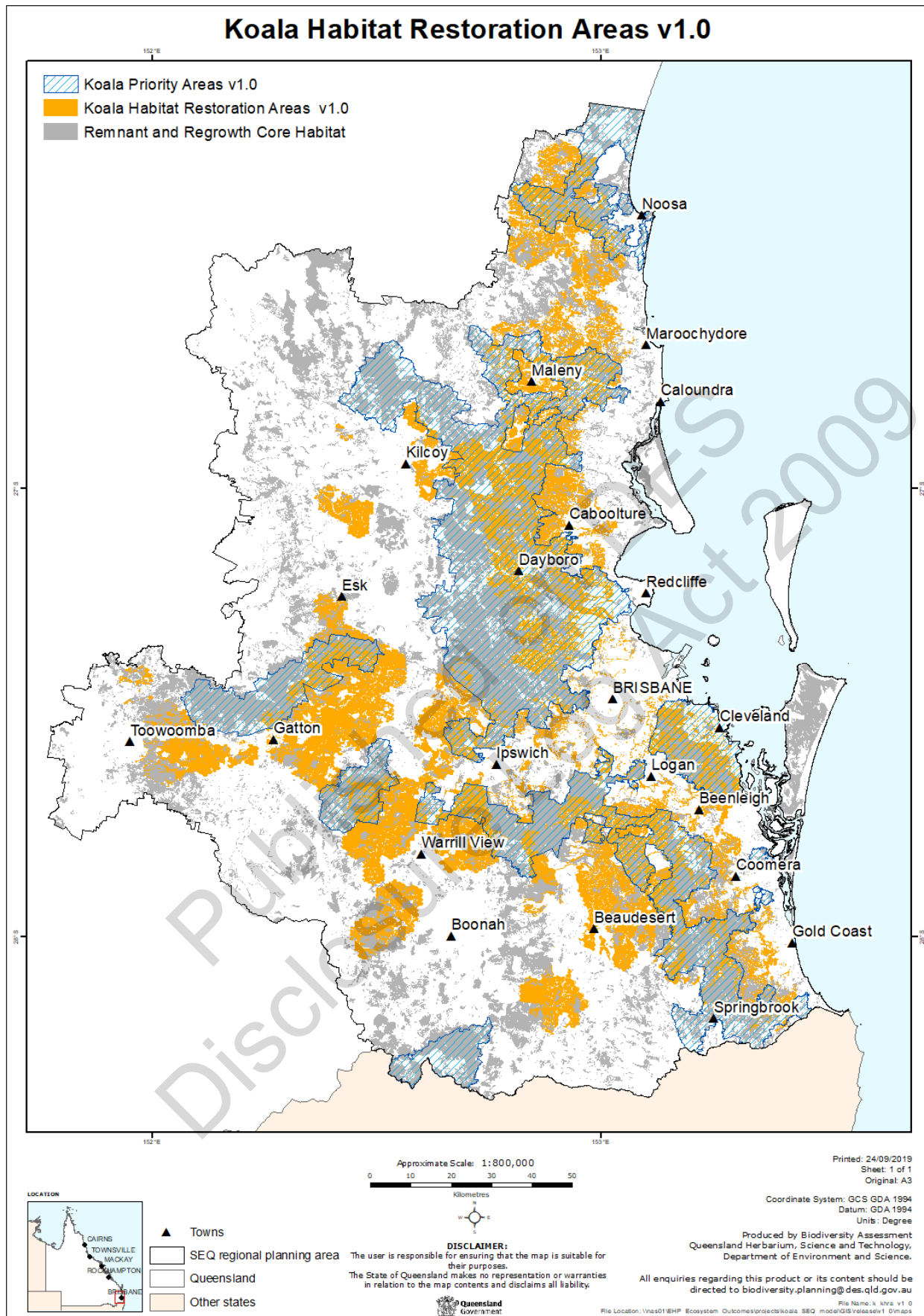


Figure 22: Marxan selection frequency used to identify KHRA.

5.2 Results

The potential for koala habitat restoration areas across SEQ was 446,846ha. The spatial distribution of KHRA areas is shown in Map 7.



Map 7: Koala Habitat Restoration Areas (KHRA).

6 Locally Refined Koala Habitat Areas (LRKHA)

6.1 Approach

To address the transition of responsibility for koala habitat conservation from local government to state government, local governments were asked to provide locally significant koala habitat areas that formed part of their koala conservation efforts. These areas are known as locally refined koala habitat areas (LRKHA).

Local government regulates areas of koala habitat that are not included in the Government's koala habitat areas. These were not included because they are not considered remnant vegetation or high value regrowth, for example because they are too fine scale or consisted of scattered trees rather than a vegetation ecosystem.

In order to provide continuous regulatory protection for the locally identified koala habitat for a 2-year period, all SEQ local governments provided details of areas for inclusion.

6.2 Methodology

Local government were asked to provide data or feedback on areas of locally important koala habitat. Table 12 shows data sources for LRKH from the 12 LGAs in the SEQ regional planning area.

Table 12 Local government area data sources for Locally Refined Koala Habitat (LRKH).

Local government area	Data
Brisbane	High, medium and low quality bushland; and high and medium quality rehabilitation from SPP mapping in koala assessable development areas ⁷ (GHD 2009) ⁸ .
Gold Coast	High, medium and low quality bushland; and high and medium quality rehabilitation from SPP mapping in koala assessable development areas (GHD 2009).
Ipswich	Koala habitat supplied by Ipswich (LG KPA V2 Supporting Koala Habitat Mapping_V2_190829.shp).
Lockyer Valley	No additional areas.
Logan	No additional areas.
Moreton Bay	High, medium and low quality bushland; and high and medium quality rehabilitation from SPP mapping in koala assessable development areas (GHD 2009).
Noosa	Koala habitat supplied by Noosa (Koala_Habitat_Area); high, medium and low quality bushland; and high and medium quality rehabilitation from SPP mapping in koala assessable development areas (GHD 2009).
Redland	High, medium and low quality bushland from SPP mapping (GHD 2009) as per data supplied by Redland (KOALA_PLANNING_AREAS_v1p2_Bushland_Erase_RE_Hab).
Scenic Rim	No additional areas.
Somerset	Australian Koala Foundation Koala Habitat Atlas supplied by Somerset (Primary_Habitat_from_KHA_REV6 and SecondaryA_Habitat_from_KHA_RE).
Sunshine Coast	No additional areas.
Toowoomba	No additional areas.

The datasets from the different LGAs were attributed with the source LGA, combined into one GIS layer and

⁷ Assessable development areas, including priority koala assessable development areas (PKADA) and koala assessable development areas (KADA)

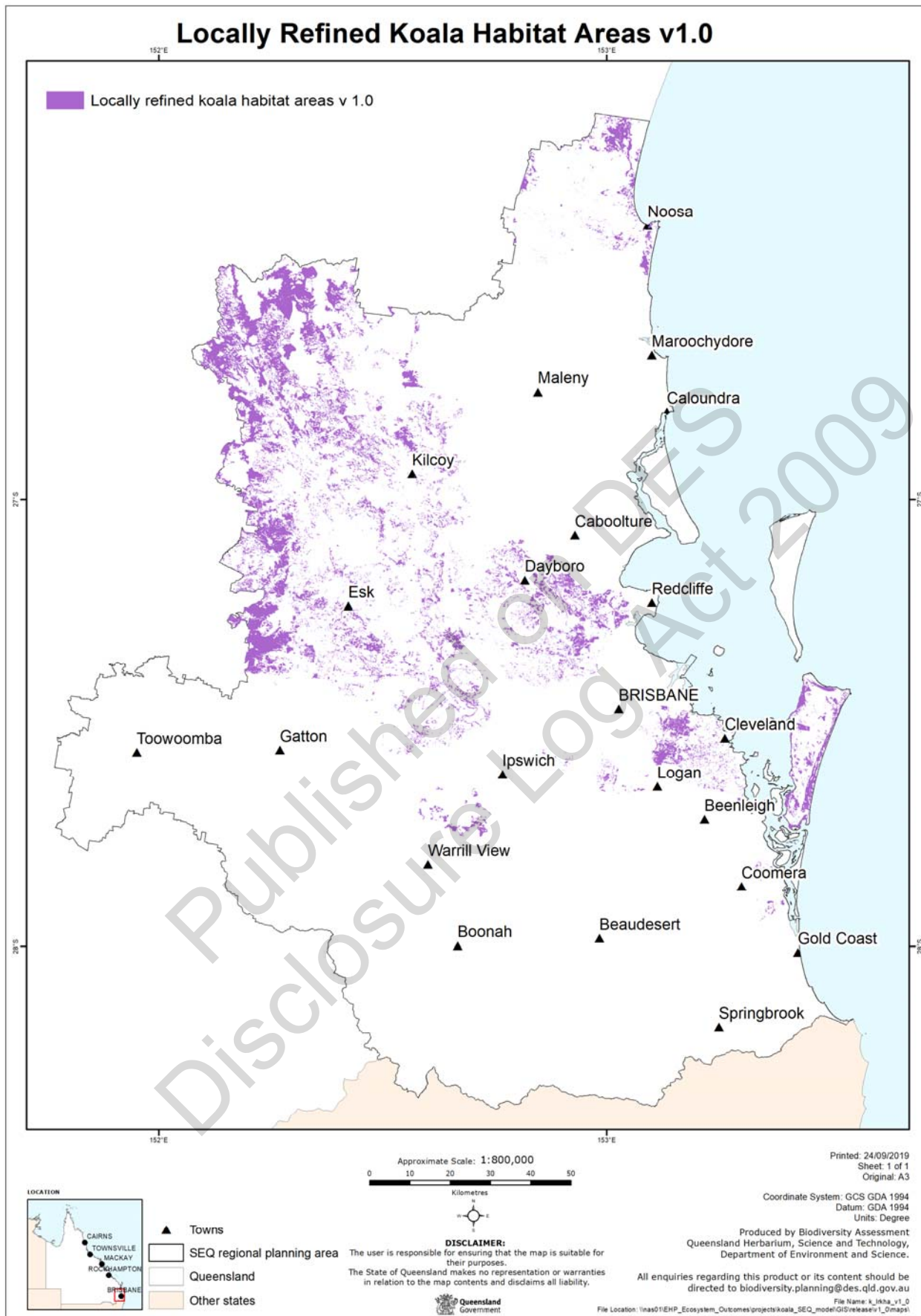
⁸ The GHD mapping was the basis of koala habitat mapping as applied under the Planning Act 2016 for southern south east Queensland.
<https://environment.des.qld.gov.au/wildlife/koalas/mapping/index.html>

dissolved on categories (high, medium and low) to simplify the data. The Identity tool in ArcGIS was used to overlay the latest Regional Vegetation Management category mapping (RVM v3.02) on the LRKH. The koala HSM was used to erase any overlap with the DES koala habit modelling.

6.3 Results

The area of LRKH was 146,200ha. The spatial distribution of LRKH areas is shown in Map 8.

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Map 8: Locally Refined Koala Habitat Areas (LRKHA)

7 Discussion

The SMPK project developed a tenure blind koala habitat mapping framework for the SEQ regional planning area by uniquely integrating a species distribution model with an expert derived RE classification and validated records of koala occurrence to produce a comprehensive map that ranks koala habitat values across the study area. The habitat model was combined with a comprehensive set of threats, constraints and opportunities which were developed to use as an ecological cost in the spatial optimisation software, Marxan. The Marxan output identified areas for koala habitat protection and restoration with lower ecological costs, which were then used by the Koala Oversight and Policy team to identify KPAs.

The new habitat modelling approach used a set of key biophysical variables with statistically tested relationship to koalas to construct a distribution model linked to the RE mapping with a set of decision rules (matrix) to determine which areas were considered 'core habitat', 'non-core habitat' and 'non-habitat' across pre-clearing, remnant and regrowth vegetation in the SEQ study area, and to rank these areas based on habitat quality for koalas. For version 1.0, only core categories of habitat were used, as these provide more suitable habitat for the long-term persistence of koala populations.

The project uniquely integrated robust mathematical modelling, with the use of Maxent, and the practical strengths and flexibility of an expert-driven assessment of vegetation suitability, to produce a koala habitat map based on a transparent and repeatable method. Areas predicted by the Maxent modelling to be highly suitable for koalas, corresponding with suitable vegetation types and confirmed by occurrence records, were mapped with a high degree of certainty. The creation of a decision matrix enabled the customisation of decision rules used to rank habitat predicted from the combination of the Maxent model and RE classification. As a result, core habitat was designated with a high level of confidence with 88% of remnant core confirmed by the presence of koala records.

Koalas are an easily identifiable species and consequently there exists a large number of incidental occurrence records where koalas have been reported across the state. Until recently it has been difficult to make use of this data due to statistical issues in dealing with potential observer bias and the lack of absence data. Technological advances, such as the development of machine learning programs like Maxent, now make it possible to use presence-only data in a robust modelling environment. This study was able to draw together a large number of koala occurrence records, not previously compiled, to confirm the presence of habitat and support the designation of core koala habitat areas.

Alternative approaches, such as the Bayesian state-space statistical models developed by Rhodes et al. (2015), were investigated for this study, however there was insufficient systematic survey data and very little absence data suitable for other methods. Rhodes et al. (2015) used 20 years of systematic survey data (which is expensive and time-consuming to collect) and found that sufficient systematic koala survey data for developing distribution models were only available from seven of the 12 LGAs in SEQ and trend data were only available from two regions (Koala Coast and Pine Rivers) where long term koala monitoring has been in place since 1995. Consequently, following a review and advice from the KEP, Maxent was chosen for the current project.

A detailed review and analysis of previous approaches to koala habitat mapping allowed the strengths and limitations of these approaches to be taken into account. Approaches previously undertaken to map koala habitat in Queensland have either focused their assessment on a set of landcover or vegetation attributes. In a review of previous koala habitat mapping, Rhodes (2014) found that there were strengths and weaknesses in both approaches and recommended that future mapping should combine the strengths of earlier approaches with robust statistical models such as Maxent. Rhodes (2014) also highlighted the need to take into account the impact of sampling and spatial bias in koala occurrence records obtained from non-systematic datasets. In this project, bias in the koala occurrence records was addressed using spatial filtering to select a subsample of records for modelling purposes. Maxent was then used to take into account a broad suite of biophysical attributes, known to be predictors of koala habitat, including terrain, soil, landcover, climate and vegetation.

Undertaking modelling using remnant and pre-clearing RE mapping value-adds to the koala mapping and ensures that it can be readily updated in line with changes to the base mapping. These links to statutory products also provide robust quality assurance and an ability to amend the mapping according to already established protocols. Similarly improvements in non-remnant mapping and the identification of regrowth used by koalas can be incorporated as it becomes available.

Modelling was undertaken in non-remnant vegetation as these areas are considered critical for koala conservation given the significant loss of core habitat to date. These areas often represent the only habitat left where food and shelter trees remain in an otherwise cleared landscape. As long as there are sufficient trees available to meet their energy requirements, regrowth or cleared areas with some trees represent little impediment to koalas as they move across the ground (rather than through the canopy) to find forage trees (White 1999). Koalas can use non-remnant vegetation and may preferentially select these areas because they often occur on fertile soils supporting a larger proportion of young trees with more palatable foliage than in remnant areas (Braithwaite et al. 1984, Cork et al. 1990, Moore et al. 2004, Lunney et al. 2000). However, over-clearing resulting in habitat loss and fragmentation not

only reduces the amount of habitat, but also increases the amount of time koalas must spend moving on the ground, which increases their risk of death from threats such as vehicles strikes or dog attacks (McAlpine et al. 2015).

The new koala habitat mapping produced by this project identified that there is currently 518,757ha of core koala habitat in the study area from a pre-clearing extent of 1,851,337ha. This represents a 72% reduction in the area of remnant core koala habitat since settlement. Of the best quality habitat, approximately 90% has been lost, with much of it situated on the high fertility, highly modified alluvial plains.

The TCOR mapping showed clearing that areas in the west of SEQ will be affected by threats such as climate change and heat stress, although there is less intensive development there and therefore constraints from urban development, for example, may be lower. This emphasises the importance of protecting and restoring koala habitat in the eastern LGAs even though these are facing more pressure from urban development. The Marxan spatial optimisation provided decision support for the identification of areas where koala habitat protection and restoration will be targeted.

7.1 Future monitoring and field surveys

7.1.1 Koala habitat monitoring

Changes in the extent of koala habitat identified in this project could be monitored over time using data from the existing woody vegetation change monitoring program conducted by the SLATS program. SLATS monitors woody vegetation loss due to land clearing on an annual basis for the entire state and could be used to assess change in the remnant core habitat modelled by this project. However, the SLATS program is generally limited to those areas where FPC is above 10 – 11% and therefore currently may not map loss of habitat from small patches of regrowth.

The SMPK project recognised the importance of non-remnant habitat for koala conservation and the recommendations of the KEP that non-remnant vegetation could be used to help redress some of the habitat loss that has occurred to date. Consequently, the project initially attempted to represent the extent of non-remnant regrowth through the use of the best data available at the time. This focused on statutory high value regrowth mapping (from the Queensland Herbarium)⁹. Current difficulties in reliably detecting and mapping non-high value regrowth should improve as new technology and remote sensing data becomes available in the future and with additional research and development by SLATS and other programs.

The Remote Sensing Centre of the former DSITI, previously undertook 'bushland extent mapping' (Muir et al. 2013) based on a combination of FPC greater than 10% (20% canopy cover) and tree height of greater than 2m, using SPOT 5, 10m multispectral imagery. This approach was considered to represent the extent of non-remnant vegetation better than the existing SLATS data. Unfortunately this analysis was not available for the whole of the SEQ study area, as it excluded two LGAs (Noosa and Toowoomba) and therefore was not suitable for this project. It is recommended that, to improve monitoring of koala habitat change over time, additional research and development is undertaken to determine the best way to detect changes in non-remnant regrowth habitat. This could include creating updated 'bushland extent mapping' (Muir et al. 2013) based upon satellite imagery that is part of a long term strategy such as the Landsat or Sentinel-2 programs. Such data could also be useful for modelling a range of other species distributions in addition to koalas.

7.1.2 Koala field surveys

The koala habitat model was developed for the 12 LGAs in the SEQ regional planning area. Currently, systematic koala survey data is only available for the seven coastal LGAs. The Southern Wildlife Operations group of DES operate a koala survey program across SEQ and could use the new habitat mapping, in combination with the collated koala occurrence records to undertake a review of future koala field surveys. The review could incorporate the habitat mapping as an input into stratifying the study area for systematic surveys and to identify sampling data gaps.

Additional systematic surveys, particularly in the five LGAs lacking systematic surveys, would provide koala density data across all of SEQ which would increase the robustness of the current model and results. Similarly with repeat survey data, currently only available for the Koala Coast and Pine Rivers, it might be possible to determine koala population trends (*sensu* Rhodes et al. 2015) so that the success of koala conservation measures can be evaluated.

The primary source of presence data used in the modelling was incidental records (obtained from WildNet, citizen science and koala hospital records). Pellet survey data from DES and other sources of incidental records could

⁹ Only the statutory high value regrowth mapping from the Queensland Herbarium was used in the koala habitat model.

also be used in future modelling reviews. Koala surveys and monitoring are critical in providing validation of the koala habitat model and can be used as inputs into future models. Additional field survey data could be used in the following ways:

Presence-absence or presence-only data

- Direct input into reviewed Maxent and habitat modelling
- Validation of the habitat model
- Repeat surveys to determine true absence

Density data (from systematic repeat surveys)

- Koala distribution
- Koala abundance
- Identification of koala hotspots (high density koala population areas and key areas for protection)
- Koala population trends

Pellet surveys

- Koala presence-absence
- Koala distribution.

7.2 Recommendations for future work

- Support the generation of improved non-remnant regrowth mapping that can be incorporated into any future koala habitat map revisions.
- Conduct further landscape analyses of the spatial modelling outputs to identify conservation values and management options that will enhance the long term viability of koalas within southern SEQ.
- Undertake field validation of the habitat mapping.
- Develop and implement monitoring procedures to quantify changes to the extent and quality of koala habitat over time.
- Investigate approaches for including confidence measures in future mapping.
- Extend the current koala habitat mapping methodology across the koalas' range in Queensland.

7.3 Limitations of the study

The aim of the SMPK project was to map areas of koala habitat based on the best available spatial data and knowledge available at the time of production. However, the project team acknowledges the following limitations:

- Inaccurate representation of non-remnant (regrowth) vegetation. Errors associated with non-regrowth areas being mapped as regrowth reflect difficulties in reliably detecting and mapping non-remnant vegetation. Future modelling would greatly benefit from purpose-built, high resolution, high accuracy non-remnant regrowth vegetation mapping.
- Some biophysical and climatic datasets were only available at coarse scales thereby reducing the reliability and operating scale of some modelled outputs.
- Given the project timeframes and confidential nature of the work, it was not possible to undertake further consultation (outside the KAG) on the model outputs or engage with local governments, local experts and other stakeholders.
- Given the project timeframes it was not possible to undertake field validation of the modelled outputs. However, the large number of koala records and the large proportion of records falling within mapped koala habitat areas, increased confidence in the model.

8 Conclusion

The SMPK project has developed a new habitat mapping framework and produced a tenure-blind koala habitat map for the SEQ regional planning area, based on the latest scientific modelling principles and data. Comprehensive threat mapping was integrated with the habitat mapping to delineate priority areas that will be the focus of koala conservation. The project used advice and input from the Koala Expert Panel and a specially formed group of koala ecologists and spatial mapping specialists (KAG). A review of previous koala mapping projects and approaches to modelling was undertaken and a significant data collation and consultation phase took place with local governments to ensure that the model represented the most comprehensive data inputs to date.

The major strength of the approach was the development of a transparent and repeatable method that can be replicated when additional or updated spatial data (such as updates to the RE and landcover mapping) becomes available. In addition, the method was developed to be adaptable to other regions, through the inclusion of relevant regionally specific datasets and rules.

In addition to the habitat mapping, the project collated a substantial range of spatial data (representing threats, constraints, opportunities and resilience) and koala occurrence records sourced from local governments and natural resource management groups. It is anticipated that integrating the koala habitat mapping with threats, constraints, opportunities and resilience measures will be useful in the identification of priority areas for koalas and for the stratification of potential future field surveys.

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Appendix 1. Vegetation data layers description and rationale

Name	Summary description and data range	Rationale for inclusion
Pre-clearing, remnant	<p>Pre-clearing vegetation is defined as the vegetation present before clearing.</p> <p>Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.</p> <p>Regional ecosystems represent vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.</p> <p>Remnant vegetation was mapped using aerial photography and satellite imagery supplied by the State Land and Tree Study (SLATS) in conjunction with field surveys as described in Neldner et al. (2019).</p> <p>Version 11.0, Queensland Herbarium 2018. Produced 14 December 2018. Based on 2017 Landsat imagery.</p> <p>Map scale range: 1:25,000 – 100,000.</p> <p>Map scales: 1:25,000 for Brisbane and Gold Coast); 1:50,000 for Moreton Bay, Redland, Sunshine Coast, Noosa, Lockyer Valley, Toowoomba and the pre-amalgamation portion of Logan; and 1:100,000 for Scenic Rim, Ipswich and Somerset. A map scale of 1:25,000 is generally used in areas covered by a property map of assessable vegetation (PMAV) (Tim Ryan 2019 pers. comm. 21 February).</p> <p>The minimum mapping unit ranges from 1ha and 35m width for linear features in areas mapped at 1:25,000 and 1:50,000 to 5ha and 75m width for linear features in areas mapped at 1:75,000 and 1:100,000.</p>	<p>Throughout their range, koalas are primarily associated with eucalypt forests (Martin et al. 2008) with some eucalypt communities, such as <i>Eucalyptus tereticornis</i> dominated woodlands which contain one of the koalas preferred browse species (Queensland blue gum), known to support high koala densities (McAlpine et al 2006; Melzer et al. 2014).</p> <p>The proportion of the landscape occupied by eucalypt and melaleuca forests and woodlands has been shown to be an important determinant of koala occurrence in Noosa Shire Council (McAlpine et al. 2006) and elsewhere across its geographic range (Rhodes et al. 2006; McAlpine et al 2008).</p>
Regrowth	<p>High value regrowth (HVR) mapping represents high conservation value native woody vegetation that has not been cleared for at least 15 years (Queensland Herbarium 2019). High value regrowth was attributed with the regional ecosystems and koala habitat suitability rankings from the pre-clearing regional ecosystem mapping.</p> <p><u>Processing</u></p> <p>The high value regrowth was produced by the Queensland Herbarium in December 2018 from an initial automated process that identified vegetation with a woody foliage projective cover of at least 11% on a consecutive sequence of satellite images indicating that it had not been cleared for at least 15 years and excluded: Areas of cropping, plantation, orchards or intensive land use and tenures not covered by VMA (e.g. national parks, state forests). The output of this process was subject to manual visual checking and editing of boundaries using high resolution imagery by botanists from DES to remove errors such as small plantations, houses and areas dominated by weedy non-native vegetation. Potential overlaps with the remnant layer were removed by erasing the regrowth layer with the current remnant regional ecosystem mapping.</p>	<p>Incorporating non-remnant habitat such as regrowth into the modelling was considered important because koalas utilise trees in fragmented landscapes and do not discriminate between remnant habitat or regrowth habitat (White 1999; Lunney et al. 2000; and Melzer et al. 2000).</p>

Appendix 2. Koala occurrence records source

Data source	Description	Number of records
DES koala database	The Biodiversity Assessment Team of DES maintains species databases that are used in biodiversity assessments and modelling for threatened species. This database was the base dataset that we added to in the project with the compilation of the records below.	42,942
DES additional records		3,425
KoalaBase	KoalaBASE is an online database and research tool that summarizes data collected on koala mortalities and morbidities in SEQ. Access to this website is limited to the chief investigators of a koala research project (KoalaBASE) based at the University of Queensland, Gatton, Australia, and their research collaborators at the Moggill Koala Hospital, Brisbane, Australia.	21,292
Local Government Consultation	Consultation occurred with all 12 local governments within the study area for the project. Seven of the 12 councils provided records from sighting databases and survey work.	
Gold Coast City Council		5,525
Redland City Council		3,470
Sunshine Coast Council		720
Moreton Bay Regional Council		683
Logan City Council		564
Scenic Rim Regional Council		118
Noosa Shire Council		101
Lockyer Community Action Inc.	The project was provided data from this community group in lieu of koala records from Lockyer Valley Regional Council.	286
Atlas of Living Australia	The Atlas of Living Australia is Australia's national biodiversity database. The database has compiled information from museums, herbaria, universities, government departments, organisations and individuals.	508
Additional DSITI WildNet data	WildNet is a computerised information system for Queensland's wildlife maintained by DSITI.	615
TOTAL		80,249

Appendix 3. Regional ecosystem koala suitability

The regional ecosystems were classified and ranked by experts for their suitability to koalas.

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
11.3.2	Eucalyptus populnea woodland to open woodland. E. melanophloia may be present and locally dominant. There is sometimes a distinct low tree layer dominated by species such as Geijera parviflora, Eremophila mitchellii, Acacia salicina, Acacia pendula, Lysiphyllum spp., Cassia brewsteri, Callitris glaucophylla and Acacia excelsa. The ground layer is grassy dominated by a range of species depending on soil and management conditions. Species include Bothriochloa decipiens, Enteropogon acicularis, Aristida ramosa and Tripogon loliiformis. Occurs on Cainozoic alluvial plains with variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays. (BVG1M: 17a)	Medium
11.3.4	Eucalyptus tereticornis woodland to open forest. Other tree species that may be present and locally dominant include E. camaldulensis, Corymbia tessellaris, E. coolabah, C. clarksoniana, E. populnea or E. brownii, E. melanophloia, E. platyphylla or Angophora floribunda. E. crebra and Lophostemon suaveolens may be locally dominant (subregion 14). A shrub layer is usually absent, and a tall grassy ground layer is often prominent, and may include any of Bothriochloa bladhii subsp. bladhii, Aristida spp., Heteropogon contortus, Dichanthium spp. and Themeda triandra. Heavily grazed areas tend to have shorter or annual grasses such as Dactyloctenium radulans or Bothriochloa spp. Occurs on Cainozoic alluvial plains and terraces. Occurs on variety of soils, including deep cracking clays, medium to fine textured soils, and deep texture-contrast soils. (BVG1M: 16c)	High
11.3.21	Grassland dominated by Dichanthium sericeum and/or Astrebla spp. (A. lappacea, A. elymoides and A. squarrosa). A wide range of other grass and forb species are usually present and may dominant depending on seasonal conditions and management regime. Frequently occurring species include the grasses Aristida leptopoda, A. latifolia, Bothriochloa bladhii subsp. bladhii, Brachyachne convergens, Heteropogon contortus, Panicum decompositum, Eriochloa spp., Sporobolus mitchellii and Thellungia advena and the forbs Abemoschus ficulneus, Corchorus trilocularis, Commelina ensifolia, Euphorbia coghlanii, Ipomoea lonchophylla, Neptunia gracilis, Phyllanthus maderaspatensis, Sida trichopoda and Trichodesma zeylanicum var. latiseipaleum. Scattered trees and shrubs may occur including Eucalyptus coolabah, E. populnea, E. tereticornis or Acacia spp. Occurs on Cainozoic alluvial plains that are near level (slope <1%), i.e. on flats associated with rivers and creeks, including back-plains, terraces, low levees and back-swamps. Associated soils are usually cracking clays that lack gilgai, are often self-mulching, usually deep and range in colour from dark grey-brown to grey or black. (BVG1M: 30a)	Non-habitat
11.3.24	Themeda avenacea +/- Eleocharis pallens grassland sometimes with scattered Duma florulenta shrubs. Occurs on depressions on Cainozoic alluvial plains. (BVG1M: 30a)	Non-habitat
11.3.25	Eucalyptus camaldulensis or E. tereticornis open forest to woodland. Other tree species such as Casuarina cunninghamiana, E. coolabah, Melaleuca bracteata, Melaleuca viminalis, Livistona spp. (in north), Melaleuca spp. and Angophora floribunda are commonly present and may be locally dominant. An open to sparse, tall shrub layer is frequently present dominated by species including Acacia salicina, A. stenophylla or Lysiphyllum carronii. Low shrubs are present, but rarely form a conspicuous layer. The ground layer is open to sparse and dominated by perennial grasses, sedges or forbs such as Imperata cylindrica, Bothriochloa bladhii, B. ewartiana, Chrysopogon fallax, Cyperus dactyloides, C. difformis, C. exaltatus, C. gracilis, C. iria, C. rigidellus, C. victoriensis, Dichanthium sericeum, Leptochloa digitata, Lomandra longifolia or Panicum spp. Occurs on fringing levees and banks of major rivers and drainage lines of alluvial plains throughout the region. Soils are very deep, alluvial, grey and brown cracking clays with or without some texture contrast. These are usually moderately deep to deep, soft or firm, acid, neutral or alkaline brown sands, loams or black cracking or non-cracking clays, and may be sodic at depth (Burgess 2003). (BVG1M: 16a)	High
11.3.26	Eucalyptus moluccana or E. woollsiana +/- E. populnea +/- E. melanophloia tall open forest to woodland +/- Allocasuarina luehmannii low tree layer and a grassy ground layer. In northern subregions, there may be shrub layer of any of Eremophila mitchellii, Flindersia dissosperma, Citrus glauca or Petalostigma pubescens, with a sparse grassy ground layer. Occurs on margins of Cainozoic alluvial plains on deep texture contrast soils. (BVG1M: 13d)	Low
11.5.2a	Allocasuarina luehmannii low tree layer with or without emergent woodland. (BVG1M: 24a)	Non-habitat
11.8.2a	Eucalyptus tereticornis and E. melliodora woodland occurring on low hills. Occurs on low hills (subregion 31 and 32) formed from basalt. The soils are generally shallow (< 60 cm deep), brown to grey-brown, gradational, clay-loams and clays. Basalt stones and boulders can occur on the surface. (BVG1M: 11a)	Medium
11.8.3	Semi-evergreen vine thicket which may have emergent Acacia harpophylla, Casuarina cristata and Eucalyptus spp. Occurs on Cainozoic igneous rocks. Generally restricted to steeper, rocky hillsides.	Very low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	(BVG1M: 7a)	
11.8.4	Eucalyptus melanophloia and/or E. crebra +/- E. orgadophila +/- Corymbia erythrophloia grassy open woodland. Macrozamia moorei is a conspicuous element of the mid layer in the Central Highlands. Localised patches of Corymbia citriodora occur on volcanic plugs such as Minerva Hills. Generally occurs on slopes of mountains and hills formed from Cainozoic igneous rocks usually with shallow stony soils and extensive outcropping. (BVG1M: 11a)	Low
11.8.5	Eucalyptus orgadophila grassy open woodland. Eucalyptus orgadophila predominates and forms a distinct but discontinuous canopy sometimes with other sub-dominant species such as Corymbia erythrophloia, E. melanophloia and occasionally E. crebra. Shrubs are usually scarce and scattered although a well-defined shrubby layer does develop in some areas. On the lower slopes at better sites, softwood scrub species may form tall and low shrub layers under the canopy of Eucalyptus orgadophila. The ground layer is moderately dense to dense, and dominated by species that include the grasses Aristida lazardis, A. ramosa, Bothriochloa ewartiana, Dichanthium sericeum, Chrysopogon fallax, Heteropogon contortus, Enneapogon gracilis, Themeda triandra and Tragus australianus and the herbs Brunoniella australis, Evolvulus alsinoides, Galactia tenuiflora and Indigofera linnaei. Occurs on undulating plains, rises, low hills or sometimes flat tablelands on top of mountains, formed from basalt. Generally soils are shallow to moderately shallow, often rocky or stony clays. (BVG1M: 11a)	Low
11.8.5a	Eucalyptus orgadophila woodland with a dense understorey of low trees species including Geijera parviflora, Callitris glaucophylla, Pittosporum angustifolium, Casuarina cristata, Alectryon oleifolius, Psydrax odorata and Notelaea microcarpa. (BVG1M: 11a)	Medium
11.8.8	Woodland usually dominated by either Eucalyptus albens or E. crebra. Eucalyptus tereticornis is an associated species that becomes locally dominant on creek lines. Other tree species that may be present include Callitris baileyi, Angophora subvelutina, Brachychiton populneus, E. melliodora, E. orgadophila, Angophora floribunda, E. moluccana, E. microcarpa, E. biturbinata, E. melanophloia and Corymbia clarksoniana. There is often a sparse low tree layer dominated by similar species to the canopy. The shrub layer is absent or sparse and consisting of species such as Cassinia laevis, Olearia elliptica, Acacia implexa, Xanthorrhoea glauca or Jacksonia scoparia. The ground layer is usually dominated by grasses of variable composition. Common species include Themeda triandra, Bothriochloa decipiens, Dichanthium sericeum, Cymbopogon refractus, Aristida spp. Forbs or sedges such as Gahnia aspera, Asperula conferta or Desmodium varians frequently occur. Occurs on hilltops and sides formed from Cainozoic basaltic rocks. (BVG1M: 11a)	Medium
11.8.11	Grassland dominated by Dichanthium sericeum, Aristida spp., Astrebla spp. and Panicum decompositum with or without trees such as Eucalyptus orgadophila, E. melanophloia, Corymbia erythrophloia and Acacia salicina, (height 11+/-3 m). However, dominance and cover may vary with seasonal and other environmental conditions. Frequently occurring and sometimes locally dominant, species include the grasses Aristida lazardis, A. ramosa, Bothriochloa ewartiana, Dichanthium sericeum, Chrysopogon fallax, Heteropogon contortus, Enneapogon gracilis, Themeda triandra and Tragus australianus and the herbs Brunoniella australis, Evolvulus alsinoides, Galactia tenuiflora and Indigofera linnaei. Isolated emergent trees (tree height 12+/-4 m - species including Eucalyptus orgadophila, E. melanophloia and Corymbia erythrophloia) or small areas of open woodland may also be present. Occurs on Cainozoic igneous rocks, particularly fresh basalt, and is generally associated with undulating to gently undulating rises. It usually occurs on the crests and middle and upper slopes (slopes 2-6%), although also present on lower slopes and flat areas (slopes 0-2%). Associated soils are moderately shallow to deep cracking clay soils, dark brown to reddish brown in colour, often self-mulching, and with gravel, stone or linear gilgai sometimes present. Surface stone 10-15 cm diameter is present in the south-western remnants. (BVG1M: 30b)	Non-habitat
11.9.5	Open forest dominated by Acacia harpophylla and/or Casuarina cristata (10-20m) or Acacia harpophylla with a semi-evergreen vine thicket understorey. Open forest dominated by C. cristata is more common in southern parts of the bioregion. A prominent low tree or tall shrub layer dominated by species such as Geijera parviflora and Eremophila mitchellii, and often with semi-evergreen vine thicket species is often present. The latter include Flindersia dissosperma, Brachychiton rupestris, Excoecaria dallachyana, Macropteranthes leichhardtii and Acalypha eremorum in eastern areas, and species such as Carissa ovata, Owenia acidula, Croton insularis, Denhamia oleaster and Notelaea microcarpa in south-western areas. Melaleuca bracteata may be present along watercourses. Occurs on fine-grained sediments. The topography includes gently undulating plains, valley floors and undulating footslopes and rarely on low hills. The soils are generally deep texture-contrast and cracking clays. The cracking clays are usually black or grey to brown or reddish-brown in colour, often self-mulching and sometimes with gilgai microrelief in flatter areas. Some texture contrast soils are shallow to only moderately deep. (BVG1M: 25a)	Very low
11.9.9	Eucalyptus crebra grassy woodland. Eucalyptus moluccana sometimes conspicuous on lower slopes. Occurs on Cainozoic to Proterozoic consolidated, fine-grained sediments. (BVG1M: 13c)	Low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.1.1	Casuarina glauca open forest to low open woodland. Occurs on margins of Quaternary estuarine deposits. (BVG1M: 28a)	Non-habitat
12.1.2	Saltpan vegetation comprising Sporobolus virginicus grassland and samphire herbland. Grasses including Zoysia macrantha subsp. macrantha sometimes present in upper portions of tidal flats. Includes saline or brackish sedgeland. Usually occurs on hypersaline Quaternary estuarine deposits. Marine plains/tidal flats. (BVG1M: 35b)	Non-habitat
12.1.3	Mangrove shrubland to low closed forest. Occurs on Quaternary estuarine deposits. (BVG1M: 35a)	Non-habitat
12.1.3b	Avicennia marina subsp. australasica dominated shrubland to low closed forest. Occurs on Quaternary estuarine deposits. Estuarine wetlands (e.g. mangroves). (BVG1M: 35a)	Non-habitat
12.1.3e	Rhizophora stylosa dominated shrubland to low closed forest. Occurs on Quaternary estuarine deposits. Estuarine wetlands (e.g. mangroves). (BVG1M: 35a)	Non-habitat
12.1.3f	Estuarine water bodies often with groundwater connectivity. Occurs on Quaternary estuarine deposits with groundwater connectivity. Estuarine wetlands (e.g. mangroves). (BVG1M: 34a)	Non-habitat
12.1.3g	Mangrove dieback area leaving bare soil or ponding. Occurs on Quaternary estuarine deposits. Estuarine wetlands (e.g. mangroves). (BVG1M: 35a)	Non-habitat
12.2.1	Notophyll/evergreen notophyll vine forest generally with abundant Archontophoenix cunninghamiana or A. alexandrae in north of bioregion. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are diagnostic of the type. Occurs on moist/wet, valley floors of parabolic dunes. (BVG1M: 4a)	Very low
12.2.2	Microphyll/notophyll vine forest. Characteristic species include Cupaniopsis anacardioides, Acronychia imperforata, Flindersia schottiana, Alectryon coriaceus, Elaeocarpus obovatus, Polyalthia nitidissima, Diospyros spp., Pleiogynium timorense and Mallotus discolor. Melaleuca spp. and eucalypt emergents may be present, e.g. Melaleuca dealbata and Corymbia tessellaris. Occurs on Quaternary coastal dunes and beaches. (BVG1M: 3a)	Very low
12.2.3	Araucarian microphyll/notophyll vine forest. Backhousia myrtifolia common in understorey on Fraser Island and Cooloolia and forms low canopy in places. Occurs on parabolic dunes. (BVG1M: 3a)	Very low
12.2.5	Open forest to low closed forest. Species can include Corymbia intermedia, Lophostemon confertus, Banksia integrifolia subsp. integrifolia, B. aemula, Callitris columellaris, Acacia spp., Livistona spp. and Endiandra sieberi. Melaleuca quinquenervia in swales. Understorey generally shrubby and can include vine forest species. Occurs on Quaternary coastal dunes, beach ridges and sandy banks of coastal streams. (BVG1M: 9f)	Low
12.2.6	Eucalyptus racemosa subsp. racemosa, Corymbia intermedia, C. gummifera, Angophora leiocarpa and E. pilularis shrubby or grassy woodland to open forest. Occurs on Quaternary coastal dunes and beaches. Dunes with deeply leached soils. (BVG1M: 9g)	Low
12.2.7	Melaleuca quinquenervia or rarely M. dealbata open forest. Other species include Eucalyptus tereticornis, Corymbia intermedia, E. bancroftii, E. latisinensis, E. robusta, Lophostemon suaveolens and Livistona decora. A shrub layer may occur with frequent species including Melastoma malabathricum subsp. malabathricum or Banksia robur. The ground layer is sparse to dense and comprised of species including the ferns Pteridium esculentum and Blechnum indicum the sedges Schoenus brevifolius, Baloskion tetraphyllum subsp. meiotachyum, Baumea rubiginosa and Gahnia sieberiana and the grass Imperata cylindrica. Occurs on Quaternary coastal dunes and seasonally waterlogged sandplains usually fringing drainage system behind beach ridge plains or on old dunes, swales and sandy coastal creek levees. (BVG1M: 22a)	Medium
12.2.7a	Melaleuca quinquenervia low woodland with Gahnia sieberiana ground layer. Occurs on Quaternary coastal sand dunes fringing swamps. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 22a)	Low
12.2.7c	Melaleuca quinquenervia, Eucalyptus robusta, Melicope elleryana open forest with understorey of Todea barbara. Occurs along watercourses on Quaternary coastal dunes and beaches and seasonally waterlogged sandplains. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 22a)	Low
12.2.8	Eucalyptus pilularis, E. microcorys, E. resinifera and Syncarpia hillii open forest. Occurs on parabolic	Low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	high dunes. (BVG1M: 8b)	
12.2.9	Banksia aemula low open woodland. Mallee eucalypts sometimes present, e.g. Eucalyptus latisinensis. Occurs on Quaternary coastal dunes and sandplains with deeply leached soils. (BVG1M: 29a)	Non-habitat
12.2.10	Mallee Eucalyptus planchoniana +/- Corymbia gummifera, E. racemosa subsp. racemosa, Banksia aemula woodland. Occurs on deeply leached Quaternary coastal dunes and sandplains. (BVG1M: 29a)	Low
12.2.12	Closed or wet heath +/- stunted emergent shrubs/low trees. Characteristic shrubs include Banksia spp. (especially B. robur) Boronia falcofolia, Epacris spp., Baeckea frutescens, Schoenus brevifolius, Leptospermum spp., Hakea actites, Melaleuca thymifolia, M. nodosa, Xanthorrhoea fulva with Baloskion spp. and Sporadanthus spp. in ground layer. Occurs on poorly drained Quaternary coastal dunes and sandplains. Low part of sand mass coastal landscapes where water collects from both overland flow and infiltration from adjoining sand dunes. (BVG1M: 29a)	Non-habitat
12.2.13	Open or dry heath. Characteristic shrubs include stunted Banksia aemula and Allocasuarina littoralis as well as Xanthorrhoea johnsonii, Leptospermum semibaccatum, Phebalium woombye, Dillwynia retorta and Caustis recurvata. Usually occurs on Pleistocene dunes and beach ridges. (BVG1M: 29a)	Non-habitat
12.2.14	Strand and fore dune complex comprising Spinifex sericeus grassland Casuarina equisetifolia subsp. incana low woodland/open forest and with Acacia leiocalyx, A. disparrima subsp. disparrima, Banksia integrifolia subsp. integrifolia, Pandanus tectorius, Corymbia tessellaris, Cupaniopsis anacardioides, Acronychia imperforata. Occurs mostly on frontal dunes and beaches but can occur on exposed parts of dunes further inland. (BVG1M: 28a)	Non-habitat
12.2.15	Closed sedgeland in coastal swamps and associated water bodies. Characteristic species include Gahnia sieberiana, Empodisma minus, Gleichenia spp., Blechnum indicum, Lepironia articulata, Baumea spp., Juncus spp., and Eleocharis spp. Occurs on Quaternary coastal dunes and beaches. Low part of coastal landscape where water collects from both overland flow and infiltration from adjoining sand dunes. (BVG1M: 34c)	Non-habitat
12.2.15a	Permanent and semi-permanent window lakes. Occurs as a window into the water table on Quaternary coastal dunes and beaches. Low part of coastal landscape where water collects from both overland flow and infiltration from adjoining sand dunes. Lacustrine wetland (e.g. lake). (BVG1M: 34a)	Non-habitat
12.2.15f	Permanent and semi-permanent perched lakes. Occurs perched on Quaternary coastal dunes. Lacustrine wetland (e.g. lake). (BVG1M: 34a)	Non-habitat
12.2.15g	Swamps dominated by Empodisma minus, Gahnia sieberiana, other sedges and forbs and shrubs such as Leptospermum liversidgei. Occurs on depressions in coastal sand masses fed by ground water. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 34c)	Non-habitat
12.2.16	Sand blows largely devoid of vegetation. Sand blows on large sand islands. (BVG1M: 28d)	Non-habitat
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, Argirodendron 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. (BVG1M: 4b)	Very low
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. (BVG1M: 8a)	Medium
12.3.3	Eucalyptus tereticornis woodland. Eucalyptus crebra and E. moluccana are sometimes present and may be relatively abundant in places, especially on edges of plains and higher level alluvium. Other species that may be present as scattered individuals or clumps include Angophora subvelutina or A. floribunda, Corymbia clarksoniana, C. intermedia, C. tessellaris, Lophostemon suaveolens and E. melanophloia. Occurs on Quaternary alluvial plains, terraces and fans where rainfall is usually less than 1000mm/y. (BVG1M: 16c)	High

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.3.3a	<i>Eucalyptus crebra</i> , <i>C. tessellaris</i> woodland to open forest. Other species that may be present as scattered individuals or clumps include <i>Corymbia clarksoniana</i> , <i>Eucalyptus melanophloia</i> , <i>E. tereticornis</i> and <i>C. citriodora</i> subsp. <i>variegata</i> . Occurs on high level alluvial plains often of Pleistocene age, terraces and fans where rainfall is usually less than 1000mm/y. Floodplain (other than floodplain wetlands). (BVG1M: 18b)	Medium
12.3.3d	<i>Eucalyptus moluccana</i> woodland. Other frequently occurring species include <i>Eucalyptus tereticornis</i> , <i>E. crebra</i> , <i>E. siderophloia</i> , <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>Angophora leiocarpa</i> and <i>C. intermedia</i> . Occurs on margins of Quaternary alluvial plains often adjacent sedimentary geologies. May also occur on stranded Pleistocene river terraces. Floodplain (other than floodplain wetlands). (BVG1M: 13d)	High
12.3.4	Open forest to woodland of <i>Melaleuca quinquenervia</i> and <i>Eucalyptus robusta</i> . Occurs fringing drainage lines and on floodplains in coastal areas. (BVG1M: 22a)	Low
12.3.4a	<i>Eucalyptus bancroftii</i> open woodland often with <i>Melaleuca quinquenervia</i> . Occurs on drainage lines and floodplains in coastal areas. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 22a)	Low
12.3.5	<i>Melaleuca quinquenervia</i> open forest to woodland. Understorey depends upon duration of water logging; sedges and ferns, especially <i>Blechnum indicum</i> , in wetter microhabitats and grasses and shrubs in drier microhabitats. Ground layer species include the grasses <i>Leersia hexandra</i> and <i>Imperata cylindrica</i> , the sedges/rushes, <i>Baumea rubiginosa</i> , <i>Gahnia sieberiana</i> , <i>Lepironia articulata</i> , <i>Schoenus brevifolius</i> and <i>Schoenus scabripes</i> and the fern <i>Lygodium microphyllum</i> . Other tree species that may be present as scattered individuals or clumps include <i>Lophostemon suaveolens</i> , <i>Eucalyptus robusta</i> , <i>E. tereticornis</i> , <i>E. bancroftii</i> , <i>E. latisinensis</i> , <i>Corymbia intermedia</i> , <i>Melaleuca salicina</i> , <i>Livistona australis</i> , <i>Casuarina glauca</i> , <i>Endiandra sieberi</i> . <i>Melastoma malabathricum</i> subsp. <i>malabathricum</i> , <i>Glochidion sumatranum</i> and <i>Melicope elleryana</i> are often in understorey. Occurs on Quaternary alluvium in coastal areas. (BVG1M: 22a)	Medium
12.3.6	<i>Melaleuca quinquenervia</i> +/- <i>Eucalyptus tereticornis</i> , <i>Lophostemon suaveolens</i> , <i>Corymbia intermedia</i> open forest to woodland with a grassy ground layer dominated by species such as <i>Imperata cylindrica</i> . <i>Eucalyptus tereticornis</i> may be present as an emergent layer. <i>Eucalyptus seeana</i> may also occur in this ecosystem to the south and east of Brisbane. Occurs on Quaternary floodplains and fringing drainage lines in coastal areas. (BVG1M: 22a)	Medium
12.3.7	Narrow fringing woodland of <i>Eucalyptus tereticornis</i> , <i>Casuarina cunninghamiana</i> subsp. <i>cunninghamiana</i> +/- <i>Melaleuca viminalis</i> . Other species associated with this RE include <i>Melaleuca bracteata</i> , <i>M. trichostachya</i> , <i>M. linariifolia</i> . North of Brisbane <i>Waterhousea floribunda</i> commonly occurs and may at times dominate this RE. <i>Melaleuca fluviatilis</i> occurs in this RE in the north of the bioregion. <i>Lomandra hystrix</i> often present in stream beds. Occurs on fringing levees and banks of rivers and drainage lines of alluvial plains throughout the region. (BVG1M: 16a)	Medium
12.3.7a	<i>Melaleuca bracteata</i> open forest +/- emergent <i>Eucalyptus tereticornis</i> . Occurs in drainage depressions on Quaternary alluvial plains. Riverine wetland or fringing riverine wetland. (BVG1M: 22c)	Low
12.3.7b	Naturally occurring instream waterholes and lagoons, both permanent and intermittent. Includes exposed stream bed and bars. Occurs in the bed of active (may be intermittent) river channels. Riverine wetland or fringing riverine wetland. (BVG1M: 16d)	Non-habitat
12.3.7c	Billabongs and ox-bow lakes containing either permanent or periodic water bodies. Often fringed with <i>Eucalyptus tereticornis</i> Old river beds now cut off from regular flow. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 34d)	Low
12.3.7d	Aquatic vegetation usually fringed with <i>Eucalyptus tereticornis</i> . Closed depressions on alluvial plains. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 34d)	Low
12.3.8	Swamps with characteristic species including <i>Cyperus</i> spp., <i>Schoenoplectus</i> spp., <i>Philydrum lanuginosum</i> , <i>Eleocharis</i> spp., <i>Leersia hexandra</i> , <i>Cynogeton procerus</i> , <i>Nymphaea</i> spp., <i>Nymphoides indica</i> , <i>Persicaria</i> spp., <i>Phragmites australis</i> , <i>Typha</i> spp. and a wide range of sedges grasses or forbs. Emergent <i>Melaleuca</i> spp. may sometimes occur. Occurs in freshwater swamps associated with floodplains. (BVG1M: 34c)	Non-habitat
12.3.8a	Swamps with characteristic species including <i>Carex appressa</i> , <i>Juncus</i> spp., <i>Persicaria</i> spp., and <i>Cyperus</i> spp. Occurs in closed depressions on the margins of elevated Tertiary basalt landscapes. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 34c)	Non-habitat

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.3.9	<i>Eucalyptus nobilis</i> open forest. Occurs at headwaters of streams on Quaternary alluvial plains usually forming a narrow fringing community. (BVG1M: 16c)	Low
12.3.10a	<i>Acacia harpophylla</i> open forest to woodland. Occurs on Quaternary alluvial plains where minor areas of cracking clay soils prevail. (BVG1M: 25a)	Very low
12.3.11	<i>Eucalyptus tereticornis</i> +/- <i>E. siderophloia</i> and <i>Corymbia intermedia</i> open forest to woodland. <i>Corymbia tessellaris</i> , <i>Lophostemon suaveolens</i> and <i>Melaleuca quinquenervia</i> frequently occur and often form a low tree layer. Other species present in scattered patches or low densities include <i>Angophora leiocarpa</i> , <i>E. exserta</i> , <i>E. grandis</i> , <i>C. trachyphloia</i> , <i>C. citriodora</i> subsp. <i>variegata</i> , <i>E. latisinensis</i> , <i>E. tindaliae</i> , <i>E. racemosa</i> and <i>Melaleuca sieberi</i> . <i>E. seeana</i> may be present south of Landsborough and <i>Livistona decora</i> 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. (BVG1M: 16c)	High
12.3.11a	Open forest of <i>Eucalyptus tereticornis</i> and/or <i>E. siderophloia</i> , <i>Lophostemon confertus</i> with vine forest understorey. Other canopy species include <i>Corymbia intermedia</i> , <i>Araucaria cunninghamii</i> and <i>Agathis robusta</i> . Frequently occurring understorey species include <i>Flindersia</i> spp., <i>Lophostemon suaveolens</i> , <i>L. confertus</i> , <i>Cupaniopsis parvifolia</i> , <i>Acronychia</i> spp., <i>Alphitonia excelsa</i> and <i>Acacia disparrima</i> subsp. <i>disparrima</i> . Occurs on sub-coastal Quaternary alluvial plains. Rainfall usually exceeds 1000mm/y. Floodplain (other than floodplain wetlands). (BVG1M: 16c)	High
12.3.11b	<i>Eucalyptus tereticornis</i> and/or <i>E. racemosa</i> subsp. <i>racemosa</i> +/- <i>E. siderophloia</i> , <i>Lophostemon suaveolens</i> , <i>E. seeana</i> , <i>E. fibrosa</i> subsp. <i>fibrosa</i> , <i>E. propinqua</i> and <i>Angophora leiocarpa</i> open forest usually with a dense shrub layer dominated by <i>Melaleuca nodosa</i> . Occurs on Quaternary alluvium usually higher Pleistocene plains and terraces. Rainfall usually exceeds 1000mm/y. Contains palustrine wetland (e.g. in swales). (BVG1M: 16c)	Medium
12.3.13	Closed or wet heathland. Characteristic species include <i>Melaleuca thymifolia</i> , <i>Banksia robur</i> , <i>Xanthorrhoea fulva</i> , <i>Hakea actites</i> , <i>Leptospermum</i> spp. and <i>Baeckea frutescens</i> . Occurs on seasonally waterlogged Quaternary alluvial plains along coastal lowlands. (BVG1M: 29a)	Non-habitat
12.3.14	<i>Banksia aemula</i> low woodland +/- mallee eucalypt low woodland. Associated canopy species include <i>Eucalyptus latisinensis</i> , <i>Corymbia intermedia</i> , <i>E. robusta</i> and <i>Lophostemon confertus</i> . Occurs on Quaternary alluvial plains along coastal lowlands. (BVG1M: 29a)	Low
12.3.14a	<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> woodland to open forest. Other canopy species may include <i>Corymbia intermedia</i> , <i>C. gummifera</i> , <i>Eucalyptus latisinensis</i> , <i>E. tindaliae</i> and <i>Melaleuca quinquenervia</i> . Occurs on Quaternary alluvial plains in near coastal areas. (BVG1M: 9g)	Low
12.3.16	Complex notophyll to microphyll vine forest. Typical canopy species include <i>Aphananthe philippinensis</i> , <i>Argyrodendron</i> sp. (Kin W.D.Francis AQ81198), <i>Argyrodendron trifoliolatum</i> , <i>Diospyros fasciculosa</i> , <i>Drypetes deplanchei</i> , <i>Dysoxylum mollissimum</i> subsp. <i>molle</i> , <i>Jagera pseudorhus</i> , <i>Mallotus discolor</i> , <i>Melia azedarach</i> , <i>Mischocarpus pyriformis</i> subsp. <i>pyriformis</i> , <i>Planchonella pohlmaniana</i> , <i>Toona ciliata</i> and <i>Vitex lignum-vitae</i> . <i>Casuarina cunninghamiana</i> may occur in scattered patches or low densities along channel banks. <i>Grevillea robusta</i> commonly occurs south of Maryborough. Emergents of <i>Araucaria cunninghamii</i> , <i>Eucalyptus tereticornis</i> and <i>Lophostemon confertus</i> may occur. Typical sub-canopy species include <i>Streblus brunonianus</i> , <i>Cryptocarya triplinervis</i> , <i>Gossia bidwillii</i> , <i>Diospyros australis</i> , <i>Arytera divaricata</i> , <i>Capparis arborea</i> , <i>Cleistanthus cunninghamii</i> and <i>Polyalthia nitidissima</i> . Occurs on Quaternary alluvial plains and channels. (BVG1M: 4b)	Very low
12.3.17	Simple notophyll fringing forest usually dominated by <i>Waterhousea floribunda</i> . Other typical canopy species include <i>Aphananthe philippinensis</i> and <i>Castanospermum australe</i> . <i>Casuarina cunninghamiana</i> may occur in scattered patches or low densities along channel banks. Often Typical sub-canopy species include <i>Syzygium australe</i> , <i>Cryptocarya triplinervis</i> and <i>Ficus coronata</i> . Fringes channels on Quaternary alluvium. (BVG1M: 4b)	Very low
12.3.18	<i>Melaleuca irbyana</i> low open forest or thicket. Emergent <i>Eucalyptus moluccana</i> , <i>E. crebra</i> , <i>E. tereticornis</i> or <i>Corymbia citriodora</i> subsp. <i>variegata</i> may be present. Occurs on Quaternary alluvial plains where drainage of soils is impeded. (BVG1M: 21b)	Medium
12.3.19	<i>Eucalyptus moluccana</i> and/or <i>Eucalyptus tereticornis</i> and <i>E. crebra</i> open forest to woodland, with a sparse to mid-dense understorey of <i>Melaleuca irbyana</i> . Occurs on margins of Quaternary alluvial plains. (BVG1M: 13d)	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.3.20	Melaleuca quinquenervia, Casuarina glauca +/- Eucalyptus tereticornis, E. siderophloia open forest. Occurs on lowest terraces of Quaternary alluvial plains in coastal areas. (BVG1M: 22a)	Medium
12.3.21	Complex microphyll vine forest. Typical canopy species include Excoecaria dallachyana, Archidendropsis thozetiana, Polyalthia nitidissima, Drypetes deplanchei, Ficus rubiginosa, Diospyros geminata, Coatesia paniculata, Flindersia australis, Alectryon connatus, Alectryon subdentatus, Diospyros humilis, Planchonella cotinifolia, Bridelia leichhardtii, Croton insularis, Denhamia pittosporoides, Notelaea microcarpa and Siphonodon australis. Casuarina cunninghamiana may occur in scattered patches or low densities along channel banks. Emergents of Araucaria cunninghamii and Eucalyptus tereticornis may occur. Typical sub-canopy species include Mallotus philippensis, Gossia bidwillii, Alangium villosum subsp. tomentosum, Exocarpos latifolius, Hodgkinsonia ovatiflora, Capparis arborea and Pleurostylia opposita. Typical shrub species include Murraya ovatifoliolata, Alchornea ilicifolia, Turraea pubescens, Alyxia ruscifolia and Psydrax odorata. Occurs on Quaternary alluvial plains and channels in drier western parts of bioregion typically draining from hills and ranges. (BVG1M: 4b)	Very low
12.5.1	Woodland complex generally with Corymbia trachyphloia, C. citriodora subsp. variegata +/- Eucalyptus crebra, E. longirostrata, C. intermedia, E. major, E. fibrosa subsp. fibrosa (can be locally common) and E. acmenoides. Localised occurrences of Eucalyptus taurina, E. decorticans, E. dura, E. cloeziana and E. melanoleuca. Understorey grassy or shrubby. Occurs on remnant Tertiary surfaces, usually with deep red soils. (BVG1M: 10b)	High
12.5.1b	Eucalyptus cloeziana open forest +/- E. microcorys and Corymbia intermedia. Occurs on remnant Tertiary surfaces. Usually deep red soils. (BVG1M: 12a)	Low
12.5.1c	Eucalyptus helidonica open forest +/- Corymbia citriodora subsp. variegata, C. trachyphloia, E. planchoniana, E. taurina, E. baileyana, Angophora woodsiana, Lysicarpus angustifolius. Occurs on remnant Tertiary surfaces. (BVG1M: 9h)	Low
12.5.1g	Eucalyptus planchoniana and/or E. baileyana woodland to open forest +/- C. trachyphloia, E. carnea, Angophora woodsiana, E. psammitica, E. crebra, E. racemosa subsp. racemosa. Occurs on remnant Tertiary surfaces. (BVG1M: 9h)	Low
12.5.2a	Corymbia intermedia, Eucalyptus tereticornis woodland. Other species can include Lophostemon suaveolens, Angophora leiocarpa, Eucalyptus acmenoides or E. portuensis, E. siderophloia or E. crebra, Corymbia tessellaris and Melaleuca quinquenervia (lower slopes). Eucalyptus exserta is usually present in northern parts of bioregion. Occurs on complex of remnant Tertiary surfaces +/- Cainozoic and Mesozoic sediments usually in coastal areas with deep red soils. (BVG1M: 9g)	High
12.5.2b	Eucalyptus tereticornis +/- Corymbia intermedia, Lophostemon suaveolens and C. citriodora subsp. variegata open forest. Other species can include Angophora leiocarpa, Eucalyptus acmenoides, E. crebra and Corymbia tessellaris. Eucalyptus exserta is usually present in northern parts of bioregion. Occurs on complex of remnant Tertiary surfaces +/- Cainozoic and Mesozoic sediments in sub-coastal areas. Usually deep red soils. (BVG1M: 9g)	Medium
12.5.2x1	Melaleuca irbyana low open forest with emergent Eucalyptus tereticornis. Occurs on remnant Tertiary surfaces, mainly deeply weathered high level Tertiary alluvium. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 21b)	Medium
12.5.3	Eucalyptus racemosa subsp. racemosa woodland with Corymbia intermedia, E. siderophloia +/- E. tindaliae, E. resinifera, E. pilularis, E. microcorys, Angophora leiocarpa. Melaleuca quinquenervia is often a prominent feature of lower slopes. Minor patches (<1ha) dominated by Corymbia citriodora subsp. variegata sometimes occur. Occurs on complex of remnant Tertiary surfaces +/- Cainozoic and Mesozoic sediments. (BVG1M: 9g)	Medium
12.5.3a	Corymbia intermedia, Eucalyptus seeana +/- E. racemosa subsp. racemosa, Angophora leiocarpa, E. siderophloia, E. microcorys, C. citriodora subsp. variegata, Lophostemon suaveolens woodland. Melaleuca quinquenervia is often a prominent feature of lower slopes. Occurs on complex of remnant Tertiary surfaces +/- Cainozoic and Mesozoic sediments. (BVG1M: 9g)	Medium
12.5.4	Eucalyptus latisinensis +/- Corymbia intermedia, C. trachyphloia subsp. trachyphloia, Angophora leiocarpa, Eucalyptus exserta woodland. Other characteristic species include Eucalyptus siderophloia, Lophostemon suaveolens, Melaleuca viridiflora var. viridiflora, M. quinquenervia, M. cheelii and Grevillea banksii. Patches of Allocasuarina luehmannii or Banksia oblongifolia present locally and Xanthorrhoea johnsonii common in ground layer. Occurs on complex of remnant Tertiary surfaces and Cainozoic and Mesozoic sediments. (BVG1M: 9g)	Low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.5.4a	Woodland of <i>Melaleuca quinquenervia</i> and/or <i>M. viridiflora</i> var. <i>viridiflora</i> +/- <i>Eucalyptus latisinensis</i> , <i>Corymbia intermedia</i> , <i>Angophora leiocarpa</i> , <i>E. exserta</i> , <i>Lophostemon suaveolens</i> and <i>M. nodosa</i> . Occurs on complex of remnant Tertiary surfaces and Cainozoic and Mesozoic sediments usually lower slopes. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 21a)	Low
12.5.6	<i>Eucalyptus siderophloia</i> , <i>E. propinqua</i> and/or <i>E. pilularis</i> open forest +/- <i>Corymbia intermedia</i> , <i>E. microcorys</i> , <i>E. acmenoides</i> , <i>E. tereticornis</i> , <i>E. biturbinata</i> , <i>Lophostemon confertus</i> with <i>E. saligna</i> , <i>E. montivaga</i> at higher altitudes. Occurs on remnant Tertiary surfaces. Usually deep red soils. (BVG1M: 9a)	High
12.5.6a	<i>Eucalyptus saligna</i> subsp. <i>saligna</i> or <i>E. grandis</i> open forest, often with vine forest understorey. Occurs on remnant Tertiary surfaces. Usually deep red soils. (BVG1M: 8a)	Low
12.5.6b	<i>Eucalyptus siderophloia</i> , <i>Corymbia intermedia</i> , <i>E. propinqua</i> or <i>E. major</i> or <i>E. longirostrata</i> open forest +/- <i>E. microcorys</i> , <i>E. acmenoides</i> , <i>E. tereticornis</i> , <i>E. biturbinata</i> , <i>E. pilularis</i> , <i>Lophostemon confertus</i> . Occurs on remnant Tertiary surfaces. Usually deep red soils. (BVG1M: 9a)	High
12.5.6c	12.5.6c: <i>Eucalyptus pilularis</i> open forest +/- <i>E. siderophloia</i> , <i>E. propinqua</i> , <i>Corymbia intermedia</i> , <i>E. microcorys</i> , <i>E. acmenoides</i> , <i>E. tereticornis</i> , <i>E. biturbinata</i> , <i>Lophostemon confertus</i> with <i>E. saligna</i> , <i>E. montivaga</i> at higher altitudes. Occurs on remnant Tertiary surfaces. Usually deep red soils. (BVG1M: 8b)	Medium
12.5.7	<i>Corymbia citriodora</i> subsp. <i>variegata</i> +/- <i>Eucalyptus portuensis</i> or <i>E. acmenoides</i> , <i>C. intermedia</i> , <i>E. fibrosa</i> subsp. <i>fibrosa</i> , <i>C. trachyphloia</i> , <i>E. moluccana</i> (lower slopes), <i>E. crebra</i> (drier sub coastal areas) or <i>E. siderophloia</i> , <i>E. exserta</i> open forest. Occurs on complex of remnant Tertiary surfaces and Tertiary sedimentary rocks. Usually deep red soils. (BVG1M: 10b)	Medium
12.5.7b	<i>Eucalyptus moluccana</i> +/- <i>Corymbia citriodora</i> subsp. <i>variegata</i> open forest. Other species include <i>Eucalyptus siderophloia</i> or <i>E. crebra</i> , <i>E. tereticornis</i> . Understorey generally sparse but can become shrubby in absence of fire. Occurs on complex of remnant Tertiary surfaces and Tertiary sedimentary rocks often on lower slopes. (BVG1M: 13d)	Medium
12.5.7c	<i>Corymbia henryi</i> and/or <i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i> woodland +/- <i>C. citriodora</i> subsp. <i>variegata</i> , <i>E. major</i> , <i>E. carnea</i> , <i>E. tindaliae</i> , <i>E. siderophloia</i> , <i>Angophora leiocarpa</i> , <i>E. helidonica</i> , <i>E. portuensis</i> , <i>E. latisinensis</i> , <i>C. intermedia</i> and <i>E. moluccana</i> . Occurs on complex of remnant Tertiary surfaces and Tertiary sedimentary rocks. (BVG1M: 10b)	Medium
12.5.9	Sedgeland to heathland often with emergent <i>Eucalyptus latisinensis</i> . Characteristic shrubs include <i>Leptospermum</i> spp., <i>Leucopogon</i> spp., <i>Ricinocarpos pinifolius</i> , <i>Strangea linearis</i> , <i>Brachyloma daphnoides</i> , <i>Persoonia virgata</i> , <i>Xanthorrhoea</i> spp., <i>Styphelia viridis</i> , <i>Monotoca scoparia</i> , <i>Woolisia pungens</i> and stunted <i>Allocasuarina littoralis</i> . Includes minor seepage areas containing <i>Banksia robur</i> and <i>Xanthorrhoea fulva</i> . Occurs on complex of remnant Tertiary surfaces and Tertiary sedimentary rocks. Lower slopes. (BVG1M: 29a)	Non-habitat
12.5.9a	<i>Melaleuca nodosa</i> low open forest to low closed-forest +/- emergent eucalypts. Occurs on poorly drained areas on remnant Tertiary surfaces including lower slopes. Contains palustrine wetland (e.g. in swales). (BVG1M: 21b)	Non-habitat
12.5.10	<i>Eucalyptus latisinensis</i> and/or <i>Banksia aemula</i> low open woodland +/- <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> . Diverse understorey of heath species. Occurs on complex of remnant Tertiary surfaces and Tertiary sedimentary rocks. (BVG1M: 29a)	Low
12.5.12	<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> , <i>E. latisinensis</i> +/- <i>Corymbia gummifera</i> , <i>C. intermedia</i> , <i>E. bancroftii</i> , <i>Melaleuca quinquenervia</i> woodland to open woodland with prominent heathy understorey. Other canopy species occasionally present include <i>E. robusta</i> , <i>Angophora leiocarpa</i> and <i>A. woodsiana</i> . Occurs on remnant Tertiary surfaces +/- Cainozoic and Mesozoic sediments. (BVG1M: 9g)	Low
12.5.13a	Microphyll to notophyll vine forest +/- <i>Araucaria cunninghamii</i> . Characteristic species include <i>Araucaria cunninghamii</i> , <i>Cupaniopsis parvifolia</i> , <i>Dendrocnide photinophylla</i> , <i>Rhodosphaera rhodanthema</i> , <i>Flindersia australis</i> , <i>F. schottiana</i> , <i>F. xanthoxyla</i> , <i>Drypetes deplanchei</i> , <i>Olea paniculata</i> , <i>Diospyros geminata</i> , <i>Gossia bidwillii</i> , <i>Excoecaria dallachyana</i> and <i>Vitex lignum-vitae</i> . <i>Argyrodendron trifoliatum</i> sometimes present especially in subregion 6. Occurs on remnant Tertiary surfaces especially lateritised basalt. (BVG1M: 5a)	Very low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.8.1	<i>Eucalyptus campanulata</i> tall open forest with shrubby to grassy understorey. Other canopy species include <i>Eucalyptus microcorys</i> , <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> , <i>E. acmenoides</i> , <i>Corymbia intermedia</i> , <i>E. carnea</i> and <i>E. resinifera</i> . Patches of <i>Eucalyptus pilularis</i> sometimes present on ridges and crests. Occurs in high rainfall areas above 580 metres altitude on Cainozoic igneous rocks especially rhyolite. (BVG1M: 8b)	Low
12.8.1a	<i>Eucalyptus montivaga</i> open forest +/- <i>Corymbia intermedia</i> , <i>E. pilularis</i> . Occurs on elevated Cainozoic igneous rocks. (BVG1M: 8b)	Low
12.8.2	<i>Eucalyptus oreades</i> +/- <i>E. campanulata</i> tall open forest. Occurs on Cainozoic igneous rocks. (BVG1M: 8a)	Non-habitat
12.8.3	Complex notophyll vine forest. Characteristic species include <i>Argyrodendron trifoliolatum</i> , <i>Olea paniculata</i> , <i>Castanospermum australe</i> , <i>Cryptocarya obovata</i> , <i>Ficus macrophylla</i> forma <i>macrophylla</i> , <i>Syzygium francisii</i> , <i>Diploglottis australis</i> , <i>Pseudoweinmannia lachnocarpa</i> , <i>Podocarpus elatus</i> , <i>Beilschmiedia obtusifolia</i> , <i>Neolitsea dealbata</i> and <i>Archontophoenix cunninghamiana</i> . Occurs on Cainozoic igneous rocks, especially basalt <600m altitude. (BVG1M: 2a)	Very low
12.8.4	Complex notophyll vine forest with scattered <i>Araucaria bidwillii</i> and <i>A. cunninghamii</i> . Characteristic species include <i>Argyrodendron actinophyllum</i> , <i>Baloghia inophylla</i> , <i>Brachychiton acerifolius</i> , <i>Dendrocnide excelsa</i> , <i>Elaeocarpus kirtonii</i> , <i>Diospyros pentamera</i> , <i>Dysoxylum fraserianum</i> , <i>Toona ciliata</i> , <i>Orites excelsus</i> and <i>Sloanea woollsii</i> . Occurs on Cainozoic igneous rocks especially basalt and lateritised basalt. (BVG1M: 2a)	Very low
12.8.5	Complex notophyll vine forest. Characteristic species include <i>Argyrodendron actinophyllum</i> , <i>Sloanea australis</i> , <i>S. woollsii</i> , <i>Cryptocarya erythroxylon</i> , <i>Ficus watkinsiana</i> , <i>Dysoxylum fraserianum</i> , <i>Ackama paniculosa</i> , <i>Karrabina benthamiana</i> , <i>Orites excelsus</i> , <i>Acmena ingens</i> , <i>Syzygium corynanthum</i> , <i>S. crebrinerve</i> and <i>Citronella moorei</i> . Occurs on Cainozoic igneous rocks especially basalt and lateritised basalt usually >600m altitude. (BVG1M: 6a)	Very low
12.8.6	Simple microphyll fern forest with <i>Nothofagus moorei</i> and/or <i>Doryphora sassafras</i> , <i>Ackama paniculosa</i> , <i>Orites excelsus</i> . Occurs on Cainozoic igneous rocks at high altitudes. (BVG1M: 6a)	Very low
12.8.7	Simple microphyll fern thicket with <i>Acmena smithii</i> . Occurs on Cainozoic igneous rocks at high altitudes. (BVG1M: 6a)	Very low
12.8.8	<i>Eucalyptus saligna</i> subsp. <i>saligna</i> or <i>E. grandis</i> tall open forest often with vine forest understorey ('wet sclerophyll'). Other species include <i>Eucalyptus microcorys</i> , <i>E. acmenoides</i> , <i>Lophostemon confertus</i> and <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> . Occurs on Cainozoic igneous rocks and areas subject to local enrichment from Cainozoic igneous rocks. (BVG1M: 8a)	Medium
12.8.8a	<i>Eucalyptus siderophloia</i> , <i>E. microcorys</i> , <i>Corymbia intermedia</i> +/- <i>Eucalyptus propinqua</i> , <i>E. carnea</i> open forest on Cainozoic igneous rocks. Occurs on Cainozoic igneous rocks and areas subject to local enrichment from Cainozoic igneous rocks. (BVG1M: 9a)	High
12.8.9	<i>Lophostemon confertus</i> 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. (BVG1M: 8a)	Low
12.8.11	<i>Eucalyptus dunnii</i> +/- <i>E. saligna</i> and <i>E. microcorys</i> tall open forest. Occurs on Cainozoic igneous rocks and areas subject to local enrichment from Cainozoic igneous rocks. (BVG1M: 8a)	Low
12.8.12	<i>Eucalyptus obliqua</i> tall open forest. Occurs on Cainozoic igneous rocks. (BVG1M: 8b)	Low
12.8.13	Microphyll and microphyll/notophyll vine forest +/- <i>Araucaria cunninghamii</i> . Characteristic species include <i>Araucaria cunninghamii</i> , <i>A. bidwillii</i> , <i>Cupaniopsis parvifolia</i> , <i>Dendrocnide photinophylla</i> , <i>Rhodospaera rhodanthema</i> , <i>Flindersia australis</i> , <i>F. schottiana</i> , <i>F. xanthoxyla</i> , <i>Drypetes deplanchei</i> , <i>Olea paniculata</i> , <i>Diospyros geminata</i> , <i>Gossia bidwillii</i> , <i>Excoecaria dallachyana</i> , <i>Pleiogynium timorense</i> (north of bioregion) and <i>Vitex lignum-vitae</i> . <i>Argyrodendron trifoliolatum</i> sometimes present especially in subregion 6. Occurs on Cainozoic igneous rocks, especially basalt. (BVG1M: 5a)	Very low
12.8.14	<i>Eucalyptus eugenioides</i> , <i>E. biturbinata</i> , <i>E. melliodora</i> +/- <i>E. tereticornis</i> , <i>Corymbia intermedia</i> , <i>E. crebra</i> open forest. <i>Allocasuarina torulosa</i> is a common understorey species. Localised occurrences of <i>Eucalyptus laevopinea</i> , <i>E. quadrangulata</i> and <i>E. banksii</i> may occur. Occurs on Cainozoic igneous rocks,	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	especially basalt. (BVG1M: 11a)	
12.8.14a	Eucalyptus moluccana open forest +/- E. tereticornis, Eucalyptus siderophloia or E. crebra. Understorey generally sparse but can become shrubby in absence of fire. Occurs on Cainozoic igneous rocks. (BVG1M: 13d)	Medium
12.8.14b	Eucalyptus quadrangulata, E. eugenioides +/- E. biturbinata tall open forest. Commonly has a moist ground layer dominated by ferns e.g. Doodia aspera. Occurs on Cainozoic igneous rocks, especially basalt usually at altitudes >800m. (BVG1M: 11a)	Non-habitat
12.8.15	Poa labillardierei var. labillardierei grassland. Occurs on Cainozoic igneous rocks. (BVG1M: 32b)	Non-habitat
12.8.16	Eucalyptus crebra, generally with E. melliodora and E. tereticornis +/- E. albens grassy woodland. Occurs on dry hillslopes on Cainozoic igneous rocks, especially basalt. (BVG1M: 11a)	Medium
12.8.17	Eucalyptus melanophloia +/- E. crebra, E. tereticornis, Corymbia tessellaris, C. intermedia and/or C. clarksoniana, E. melliodora, Angophora subvelutina grassy woodland. Occurs on Cainozoic igneous rocks, especially basalt. (BVG1M: 11a)	Medium
12.8.18	Simple notophyll vine forest, generally with Ceratopetalum apetalum and Lophostemon confertus. Other characteristic species include Ackama paniculosa, Karrabina benthamiana and Orites excelsus. Occurs on Cainozoic igneous rocks, in particular less fertile substrates such as rhyolite. (BVG1M: 6a)	Very low
12.8.19	Heath and rock pavement with scattered shrubs or open woodland. Occurs on Cainozoic igneous rocks especially rhyolite and trachyte. (BVG1M: 29b)	Non-habitat
12.8.20	Low shrubby woodland to open woodland complex. Canopy trees include Eucalyptus racemosa subsp. racemosa, E. dura, Corymbia trachyphloia, E. carnea, Allocasuarina littoralis, Acacia spp. and Lophostemon confertus. Occurs on Cainozoic igneous rocks, especially rhyolite. (BVG1M: 9h)	Low
12.8.21	Low microphyll vine forest and semi-evergreen vine thicket +/- Araucaria cunninghamii. Characteristic species include Brachychiton rupestris, Flindersia collina, F. australis, Alectryon diversifolius, A. subdentatus, Elattostachys xylocarpa, Erythroxylum sp. (Splityard Creek L. Pedley 5360), Psydrax odorata forma buxifolia, Diospyros geminata, Planchonella cotinifolia, Croton insularis, Bridelia exaltata and Bursaria incana. Melaleuca bracteata is often present along watercourses. Occurs on Cainozoic igneous rocks, especially basalt. (BVG1M: 7a)	Very low
12.8.23	Acacia harpophylla +/- semi-evergreen vine thicket species +/- Casuarina cristata +/- Eucalyptus populnea tall open forest. Occurs on Cainozoic igneous rocks, especially basalt. (BVG1M: 25a)	Very low
12.8.24	Corymbia citriodora subsp. variegata, Eucalyptus crebra +/- E. moluccana open forest. Occurs on Cainozoic igneous rocks especially lower slopes of rhyolite and trachyte hills (e.g. Moogerah Peaks). (BVG1M: 10b)	Low
12.8.25	Open forest with Eucalyptus acmenoides or E. helidonica +/- E. eugenioides, E. crebra, E. propinqua, Corymbia intermedia, E. biturbinata, E. moluccana and Lophostemon confertus. Occurs on Cainozoic igneous rocks especially trachyte hills. (BVG1M: 9g)	Medium
12.8.27	Grassland of Bothriochloa bladhii, Themeda triandra, Dichanthium sericeum +/- Bothriochloa biloba. Small stands of Eucalyptus melanophloia or Corymbia tessellaris may occur throughout. Occurs on undulating low hills consisting of heavy black clay soil derived from basalt. (BVG1M: 30b)	Non-habitat
12.9-10.1	Tall open forest. Canopy species include Eucalyptus resinifera, E. grandis, E. robusta, Corymbia intermedia +/- E. microcorys, Melaleuca quinquenervia, Syncarpia glomulifera subsp. glomulifera and Lophostemon confertus. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 8a)	Medium
12.9-10.2	Corymbia citriodora subsp. variegata open forest or woodland usually with Eucalyptus crebra. Other species such as Eucalyptus tereticornis, E. moluccana, E. acmenoides and E. siderophloia may be present in scattered patches or in low densities. Understorey can be grassy or shrubby. Shrubby understorey of Lophostemon confertus (whipstick form) often present in northern parts of bioregion. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 10b)	Medium
12.9-10.3	Eucalyptus moluccana open forest. Other canopy species include Eucalyptus siderophloia or E. crebra,	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	<i>E. tereticornis</i> and <i>Corymbia citriodora</i> subsp. <i>variegata</i> . Understorey generally sparse but can become shrubby in absence of fire. Occurs on Cainozoic and Mesozoic sediments, especially shales. Prefers lower slopes. (BVG1M: 13d)	
12.9-10.4	<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> woodland to open forest. Other species can include <i>Angophora leiocarpa</i> , <i>Eucalyptus seeana</i> , <i>E. siderophloia</i> , <i>Corymbia intermedia</i> , <i>E. tindaliae</i> , with <i>Lophostemon suaveolens</i> , <i>Melaleuca quinquenervia</i> , <i>E. tereticornis</i> common on lower slopes. Occurs on Cainozoic and Mesozoic sediments +/- remnant Tertiary surfaces. (BVG1M: 9g)	High
12.9-10.4a	<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> woodland to open woodland with a wet ground layer often dominated by <i>Ptilothrix deusta</i> , <i>Lepidosperma laterale</i> var. <i>laterale</i> and other sedges and grasses. Other canopy species can include <i>Corymbia gummifera</i> , <i>C. intermedia</i> , <i>Melaleuca quinquenervia</i> , <i>Lophostemon suaveolens</i> and <i>Eucalyptus resinifera</i> . A secondary tree layer of <i>Melaleuca quinquenervia</i> , <i>Lophostemon suaveolens</i> , <i>Allocasuarina littoralis</i> may also be present. Occurs on moist lower slopes and discharge areas on Cainozoic and Mesozoic sediments +/- remnant Tertiary surfaces. Palustrine wetland (e.g. vegetated swamp). (BVG1M: 9g)	Medium
12.9-10.5	Shrubby woodland complex. More widely distributed and abundant species include <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> , <i>C. citriodora</i> subsp. <i>variegata</i> , <i>Eucalyptus crebra</i> , <i>E. fibrosa</i> subsp. <i>fibrosa</i> , <i>E. major</i> , <i>Angophora leiocarpa</i> , <i>E. helidonica</i> . Understorey of sclerophyllous shrubs. Localised occurrences of <i>Eucalyptus baileyana</i> , <i>E. pilularis</i> , <i>Corymbia henryi</i> , <i>E. dura</i> , <i>E. decorticans</i> (extreme west of bioregion), <i>E. taurina</i> , <i>Angophora woodsiana</i> , <i>Lysicarpus angustifolius</i> and <i>Lophostemon confertus</i> . Tends to shrubland or monospecific woodland of species such as <i>Eucalyptus dura</i> on shallow lithosols. Occurs on quartzose sandstone scarps and crests. (BVG1M: 9h)	Medium
12.9-10.5a	<i>Eucalyptus helidonica</i> , <i>Corymbia citriodora</i> subsp. <i>variegata</i> open forest +/- <i>C. trachyphloia</i> subsp. <i>trachyphloia</i> , <i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i> , <i>E. taurina</i> , <i>E. dura</i> , <i>E. baileyana</i> , <i>C. gummifera</i> , <i>Angophora woodsiana</i> and <i>Lysicarpus angustifolius</i> . Occurs on quartzose sandstone scarps and crests. (BVG1M: 9h)	Low
12.9-10.5d	Woodland of <i>Eucalyptus eugenioides</i> , <i>E. biturbinata</i> or <i>E. longirostrata</i> , <i>E. crebra</i> , <i>E. tereticornis</i> and <i>Corymbia trachyphloia</i> . Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 9h)	Medium
12.9-10.6	<i>Acacia harpophylla</i> open forest +/- <i>Casuarina cristata</i> and vine thicket species. Occurs on Cainozoic and Mesozoic sediments, especially fine-grained rocks. (BVG1M: 25a)	Very low
12.9-10.7	<i>Eucalyptus crebra</i> +/- <i>E. tereticornis</i> , <i>Corymbia tessellaris</i> , <i>Angophora leiocarpa</i> , <i>E. melanophloia</i> woodland. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 13c)	Medium
12.9-10.7a	<i>Eucalyptus siderophloia</i> , <i>Corymbia intermedia</i> +/- <i>E. tereticornis</i> and <i>Lophostemon confertus</i> open forest. Occurs on Cainozoic and Mesozoic sediments in near coastal areas. (BVG1M: 12a)	Medium
12.9-10.8	<i>Eucalyptus melanophloia</i> grassy woodland, usually with <i>E. crebra</i> , <i>Eucalyptus tereticornis</i> +/- <i>Corymbia tessellaris</i> , <i>C. erythrophloia</i> and <i>Angophora</i> spp. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 17b)	Medium
12.9-10.10	<i>Melaleuca nodosa</i> low open forest or thicket, usually with <i>Melaleuca sieberi</i> and emergent <i>Eucalyptus</i> spp. Occurs on Cainozoic and Mesozoic sediments in coastal areas. (BVG1M: 21b)	Non-habitat
12.9-10.11	<i>Melaleuca irbyana</i> low open forest or thicket. Emergent <i>Eucalyptus moluccana</i> , <i>E. crebra</i> , <i>E. tereticornis</i> or <i>Corymbia citriodora</i> subsp. <i>variegata</i> may be present. Occurs on Mesozoic sediments where drainage of soils is impeded. (BVG1M: 21b)	Medium
12.9-10.12	<i>Corymbia intermedia</i> , <i>Angophora leiocarpa</i> , <i>Eucalyptus seeana</i> +/- <i>E. siderophloia</i> , <i>E. tereticornis</i> , <i>E. racemosa</i> subsp. <i>racemosa</i> , <i>C. citriodora</i> subsp. <i>variegata</i> woodland to open forest. <i>E. seeana</i> and <i>Lophostemon suaveolens</i> are often present as sub-canopy or understorey trees. Occasional <i>Melaleuca quinquenervia</i> on lower slopes. Does not include areas dominated by <i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> . Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 9g)	Medium
12.9-10.14	<i>Eucalyptus pilularis</i> tall open forest with shrubby understorey. Other species include <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> , <i>S. verecunda</i> , <i>Corymbia intermedia</i> , <i>Angophora woodsiana</i> and <i>Eucalyptus microcorys</i> in coastal areas and species of RE 12.9-10.5 in drier sub coastal areas. <i>Eucalyptus pilularis</i> sometimes extends onto colluvial lower slopes. Occurs on Cainozoic and Mesozoic sediments especially sandstone. (BVG1M: 8b)	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.9-10.14a	Open forest of <i>Eucalyptus grandis</i> , <i>Lophostemon confertus</i> , <i>E. microcorys</i> , <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> +/- <i>E. pilularis</i> . Occurs on Cainozoic and Mesozoic sediments especially sandstone in wet gullies and southern slopes. (BVG1M: 8a)	Medium
12.9-10.14b	<i>Eucalyptus pilularis</i> open forest. Other canopy species may include <i>Angophora woodsiana</i> , <i>Eucalyptus baileyana</i> , <i>Corymbia henryi</i> , <i>C. trachyphloia</i> , <i>E. taurina</i> , and <i>E. microcorys</i> . Occurs in dry sub coastal areas on Cainozoic and Mesozoic sediments especially quartzose sandstone. (BVG1M: 8b)	Medium
12.9-10.15	Low microphyll vine forest +/- <i>Araucaria cunninghamii</i> and semi-evergreen vine thicket. Characteristic species include <i>Brachychiton rupestris</i> , <i>Flindersia collina</i> , <i>F. australis</i> , <i>Alectryon diversifolius</i> , <i>A. subdentatus</i> , <i>Elatostachys xylocarpa</i> , <i>Erythroxylum</i> sp. (Splityard Creek L. Pedley 5360), <i>Psydrax odorata</i> forma <i>buxifolia</i> , <i>Diospyros geminata</i> , <i>Planchonella cotinifolia</i> , <i>Croton insularis</i> , <i>Bridelia exaltata</i> and <i>Bursaria incana</i> . <i>Melaleuca bracteata</i> is often present along watercourses. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 7a)	Very low
12.9-10.16	Microphyll to notophyll vine forest +/- <i>Araucaria cunninghamii</i> . Characteristic species include <i>Argyrodendron</i> sp. (Kin W.D. Francis AQ81198), <i>Araucaria cunninghamii</i> , <i>Agathis robusta</i> , <i>Backhousia myrtifolia</i> , <i>Cupaniopsis parvifolia</i> , <i>Dendrocnide photinophylla</i> , <i>Rhodosphaera rhodanthema</i> , <i>Flindersia australis</i> , <i>F. xanthoxyla</i> , <i>Drypetes deplanchei</i> , <i>Olea paniculata</i> , <i>Diospyros geminata</i> , <i>Gossia bidwillii</i> , <i>Excoecaria dallachyana</i> and <i>Vitex lignum-vitae</i> . <i>Archontophoenix cunninghamiana</i> often present in gully floors. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 5a)	Very low
12.9-10.17	Open forest to woodland complex generally with a variety of stringybarks, grey gums, ironbarks and in some areas spotted gum. Canopy trees include <i>Eucalyptus siderophloia</i> , <i>E. propinqua</i> or <i>E. major</i> , <i>E. acmenoides</i> or <i>E. portuensis</i> , <i>E. carnea</i> and/or <i>E. microcorys</i> and/or <i>Corymbia citriodora</i> subsp. <i>variegata</i> . Other species that may be present locally include <i>Corymbia intermedia</i> , <i>C. trachyphloia</i> , <i>Eucalyptus tereticornis</i> , <i>E. biturbinata</i> , <i>E. moluccana</i> , <i>E. longirostrata</i> , <i>E. fibrosa</i> subsp. <i>fibrosa</i> and <i>Angophora leiocarpa</i> . <i>Lophostemon confertus</i> or Whipstick <i>Lophostemon confertus</i> often present in gullies and as a sub-canopy or understorey tree. Mixed understorey of grasses, shrubs and ferns. Hills and ranges of Cainozoic and Mesozoic sediments. (BVG1M: 9a)	High
12.9-10.17a	<i>Lophostemon confertus</i> or <i>L. suaveolens</i> dominated open forest usually with emergent <i>Eucalyptus</i> and/or <i>Corymbia</i> species. Occurs in gullies and southern slopes on Cainozoic and Mesozoic sediments. (BVG1M: 28e)	Low
12.9-10.17b	<i>Corymbia citriodora</i> subsp. <i>variegata</i> mixed open forest to woodland. Other commonly occurring canopy trees include <i>Eucalyptus acmenoides</i> , <i>Angophora leiocarpa</i> , <i>E. siderophloia</i> , <i>E. carnea</i> , <i>E. longirostrata</i> and <i>C. intermedia</i> . Other species that may be present locally include <i>Eucalyptus tereticornis</i> , <i>E. crebra</i> , <i>E. fibrosa</i> subsp. <i>fibrosa</i> and <i>E. exserta</i> . <i>Lophostemon confertus</i> (tree form and whipstick form) often present in gullies and as a sub-canopy or understorey tree. Mixed understorey of grasses and shrubs. Hills and ranges of Cainozoic and Mesozoic sediments usually with > 1000mm rainfall per annum. (BVG1M: 10b)	High
12.9-10.17c	Open forest of <i>Eucalyptus carnea</i> and/or <i>E. tindaliae</i> and/or <i>E. helidonica</i> +/- <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>Eucalyptus crebra</i> , <i>Eucalyptus major</i> , <i>Corymbia henryi</i> , <i>Angophora woodsiana</i> , <i>C. trachyphloia</i> , <i>E. siderophloia</i> , <i>E. microcorys</i> , <i>E. resinifera</i> and <i>E. propinqua</i> . <i>Lophostemon confertus</i> often present as a sub-canopy or understorey tree. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 9g)	High
12.9-10.17d	Open forest generally containing <i>Eucalyptus siderophloia</i> , <i>E. propinqua</i> or <i>E. major</i> , <i>Corymbia intermedia</i> . Other characteristic species include <i>Lophostemon confertus</i> , <i>Eucalyptus microcorys</i> and <i>E. acmenoides</i> or <i>E. portuensis</i> . Other species that may be present locally include <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> , <i>C. citriodora</i> subsp. <i>variegata</i> , <i>E. longirostrata</i> , <i>E. carnea</i> , <i>E. moluccana</i> and occasional vine forest species. Hills and ranges on Cainozoic and Mesozoic sediments. (BVG1M: 9a)	High
12.9-10.17e	<i>Eucalyptus acmenoides</i> , <i>E. propinqua</i> , <i>Corymbia intermedia</i> +/- <i>E. microcorys</i> , <i>Lophostemon confertus</i> open forest. Mixed understorey of grasses, shrubs and ferns. Hills and ranges of Cainozoic and Mesozoic sediments. (BVG1M: 9a)	Medium
12.9-10.18	<i>Angophora leiocarpa</i> , <i>Eucalyptus crebra</i> woodland +/- <i>E. longirostrata</i> , <i>Corymbia citriodora</i> subsp. <i>variegata</i> . Other species such as <i>Eucalyptus tereticornis</i> , <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> and <i>C. intermedia</i> may be present in scattered patches or in low densities. Understorey can be grassy or shrubby. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 9h)	Medium
12.9-10.19	<i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i> woodland +/- <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>E. acmenoides</i> or <i>E. portuensis</i> , <i>Angophora leiocarpa</i> , <i>E. major</i> . Understorey often sparse. Localised occurrences of	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	<i>Eucalyptus sideroxyloides</i> . Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 12a)	
12.9-10.19a	<i>Corymbia henryi</i> and/or <i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i> open forest. Other commonly associated species include, <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>E. carnea</i> , <i>E. siderophloia</i> , <i>E. crebra</i> and <i>E. major</i> . Occurs in coastal areas on Cainozoic and Mesozoic sediments. (BVG1M: 10b)	Medium
12.9-10.21	<i>Eucalyptus acmenoides</i> or <i>E. portuensis</i> woodland usually with <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> +/- <i>Angophora leiocarpa</i> , <i>E. major</i> , <i>E. moluccana</i> , <i>E. exserta</i> , <i>Lophostemon confertus</i> (whipstick form). Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 9h)	Medium
12.9-10.22	Closed sedgeland to heathland with emergent trees. Characteristic species include <i>Schoenus brevifolius</i> and/or <i>Baumea juncea</i> and/or <i>Banksia robur</i> and/or <i>Melaleuca nodosa</i> . Sometimes grading into <i>Banksia aemula</i> woodland on rises. Usually occurs on lower slopes subject to periodic water logging on Cainozoic and Mesozoic sediments. (BVG1M: 34f)	Non-habitat
12.9-10.26	<i>Eucalyptus baileyana</i> and/or <i>E. planchoniana</i> woodland to open forest. Other commonly associated species include <i>Angophora woodsiana</i> , <i>E. tindaliae</i> , <i>E. carnea</i> , <i>E. resinifera</i> . <i>Eucalyptus psammitica</i> may dominate areas of this ecosystem occurring in Toohey Forest. Occurs on quartzose sandstone scarps and crests. (BVG1M: 12a)	Medium
12.9-10.27	<i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>Eucalyptus crebra</i> and/or <i>E. moluccana</i> , <i>E. tereticornis</i> open forest with a sparse to mid-dense understorey of <i>Melaleuca irbyana</i> . Occurs on lower slopes and elevated flats with impeded drainage on Mesozoic sediments. (BVG1M: 10b)	Medium
12.9-10.28	<i>Angophora leiocarpa</i> , <i>Eucalyptus interstans</i> +/- <i>Corymbia intermedia</i> , <i>E. tereticornis</i> <i>C. tessellaris</i> , <i>C. clarksoniana</i> , <i>C. gummifera</i> , <i>E. siderophloia</i> , <i>C. citriodora</i> subsp. <i>variegata</i> woodland to open forest. <i>Lophostemon suaveolens</i> is often present as a sub-canopy or understorey tree. Occasional <i>Melaleuca quinquenervia</i> on lower slopes. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 9g)	High
12.9-10.29	<i>Eucalyptus cloeziana</i> +/- <i>E. propinqua</i> , <i>E. acmenoides</i> , <i>E. microcorys</i> and <i>E. grandis</i> tall open forest. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 8a)	Medium
12.11.1	Evergreen notophyll vine forest and/or <i>Lophostemon confertus</i> closed forest. <i>Archontophoenix cunninghamiana</i> 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. (BVG1M: 4a)	Very low
12.11.2	Tall open forest with vine forest understorey ('wet sclerophyll'). Canopy species include <i>Eucalyptus saligna</i> subsp. <i>saligna</i> or <i>E. grandis</i> , <i>E. microcorys</i> , <i>Corymbia intermedia</i> and <i>Lophostemon confertus</i> . Characteristic understorey species include <i>Ackama paniculosa</i> , <i>Pittosporum undulatum</i> , <i>Synoum glandulosum</i> subsp. <i>glandulosum</i> and <i>Cryptocarya microneura</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 8a)	Medium
12.11.3	<i>Eucalyptus siderophloia</i> and <i>E. propinqua</i> open forest +/- <i>E. microcorys</i> , <i>Lophostemon confertus</i> , <i>Corymbia intermedia</i> , <i>E. biturbinata</i> , <i>E. acmenoides</i> , <i>E. tereticornis</i> , <i>E. moluccana</i> , <i>Angophora leiocarpa</i> , <i>Syncarpia verecunda</i> with vine forest species and <i>E. grandis</i> or <i>E. saligna</i> in gullies. <i>Eucalyptus pilularis</i> and <i>E. tindaliae</i> 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. (BVG1M: 9a)	Medium
12.11.3a	<i>Lophostemon confertus</i> +/- <i>Eucalyptus microcorys</i> , <i>E. carnea</i> , <i>E. propinqua</i> , <i>E. major</i> , <i>E. siderophloia</i> woodland. Occurs in gullies and exposed ridges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 9a)	Medium
12.11.3b	<i>Eucalyptus pilularis</i> tall open forest. Other frequently occurring species include <i>Eucalyptus microcorys</i> , <i>E. saligna</i> , <i>E. siderophloia</i> , <i>E. carnea</i> , <i>Corymbia intermedia</i> and <i>E. propinqua</i> . Occurs on higher altitude (>300m) subcoastal hills and ranges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 8b)	High
12.11.5	<i>Corymbia citriodora</i> subsp. <i>variegata</i> open forest to woodland, usually including <i>Eucalyptus siderophloia</i> / <i>E. crebra</i> (sub coastal ranges), <i>E. propinqua</i> and <i>E. acmenoides</i> or <i>E. carnea</i> . Other species that may be present and abundant locally include <i>Corymbia intermedia</i> , <i>C. trachyphloia</i> subsp. <i>trachyphloia</i> , <i>Eucalyptus tereticornis</i> , <i>E. microcorys</i> , <i>E. portuensis</i> , <i>E. helidonica</i> , <i>E. major</i> , <i>E. longirostrata</i> , <i>E. biturbinata</i> , <i>E. moluccana</i> and <i>Angophora leiocarpa</i> . <i>Lophostemon confertus</i> often present in gullies and as a sub-canopy or understorey tree. Mixed understorey of grasses, shrubs and	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	ferns. Occurs on hills and ranges of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 10b)	
12.11.5m	Heath and rock pavement with scattered shrubs or open woodland. Canopy trees include <i>Eucalyptus carnea</i> and <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>Corymbia intermedia</i> and <i>Lophostemon confertus</i> . Occurs on ridges and crests comprised of chert or other highly resistant Palaeozoic and older moderately to strongly deformed and metamorphosed sediments. (BVG1M: 29b)	Non-habitat
12.11.6	Open forest to woodland of <i>Corymbia citriodora</i> subsp. <i>variegata</i> generally with <i>Eucalyptus crebra</i> . Other species such as <i>Eucalyptus exserta</i> , <i>E. tereticornis</i> , <i>E. moluccana</i> , <i>E. melanophloia</i> , <i>E. acmenoides</i> , <i>Corymbia tessellaris</i> and <i>Angophora leiocarpa</i> may be present in scattered patches or in low densities. Understorey grassy or shrubby. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. Drier habitats than RE 12.11.5. (BVG1M: 10b)	Medium
12.11.7	<i>Eucalyptus crebra</i> woodland. Other species such as <i>Corymbia clarksoniana</i> may be present in low densities or in patches. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 13c)	Low
12.11.8	<i>Eucalyptus melanophloia</i> usually with <i>E. crebra</i> grassy woodland. Other species such as <i>Corymbia erythrophloia</i> , <i>C. tessellaris</i> , <i>C. clarksoniana</i> may be present in low densities or in patches. Restricted occurrence of <i>Callitris glaucophylla</i> south of Gayndah. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 17b)	Low
12.11.9	Open forest to woodland with <i>Eucalyptus tereticornis</i> . Includes both <i>E. tereticornis</i> subsp. <i>tereticornis</i> and <i>E. tereticornis</i> subsp. <i>basaltica</i> . Other canopy species include <i>Eucalyptus biturbinata</i> , <i>E. melliodora</i> , <i>Corymbia intermedia</i> , <i>E. longirostrata</i> , <i>E. eugenoides</i> , <i>Allocasuarina torulosa</i> , <i>E. moluccana</i> , <i>E. saligna</i> , <i>E. siderophloia</i> and <i>Angophora subvelutina</i> . 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. (BVG1M: 9g)	Medium
12.11.9x1	<i>Eucalyptus montivaga</i> open forest. Other canopy species can include <i>Corymbia trachyphloia</i> , <i>E. acmenoides</i> , <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> and <i>C. intermedia</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. Altitude >500m. (BVG1M: 8b)	Low
12.11.10	Notophyll and notophyll/microphyll vine forest +/- <i>Araucaria cunninghamii</i> . Characteristic species include <i>Argyrodendron trifoliolatum</i> , <i>Argyrodendron</i> sp. (Kin W.D.Francis AQ81198), <i>Backhousia subargentea</i> , <i>Dissiliaria baloghoides</i> , <i>Brachychiton discolor</i> , <i>Beilschmiedia obtusifolia</i> , <i>Diospyros pentamera</i> , <i>Grevillea robusta</i> , <i>Gmelina leichhardtii</i> and <i>Ficus macrophylla</i> forma <i>macrophylla</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 2a)	Very low
12.11.11	Microphyll vine forest +/- <i>Araucaria cunninghamii</i> . Characteristic species include <i>Araucaria cunninghamii</i> , <i>Cupaniopsis parvifolia</i> , <i>Dendrocnide photinophylla</i> , <i>Rhodosphaera rhodanthema</i> , <i>Flindersia australis</i> , <i>F. xanthoxyla</i> , <i>Drypetes deplanchei</i> , <i>Olea paniculata</i> , <i>Diospyros geminata</i> , <i>Gossia bidwillii</i> , <i>Excoecaria dallachyana</i> and <i>Vitex lignum-vitae</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 5a)	Very low
12.11.14	<i>Eucalyptus crebra</i> , <i>E. tereticornis</i> , <i>Corymbia intermedia</i> grassy woodland. Other species including <i>Eucalyptus melanophloia</i> , <i>Corymbia clarksoniana</i> , <i>C. erythrophloia</i> , <i>C. tessellaris</i> , <i>E. siderophloia</i> , <i>Angophora</i> spp. May be present in low densities or in patches. Mid-layer generally sparse but can include low trees such as <i>Vachellia bidwillii</i> , <i>Capparis</i> spp., <i>Dodonaea triquetra</i> , <i>Alphitonia excelsa</i> and <i>Xanthorrhoea</i> spp. Occurs on mid and lower slopes on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 13c)	Medium
12.11.15	<i>Eucalyptus tereticornis</i> , <i>Corymbia intermedia</i> open woodland +/- <i>E. acmenoides</i> , <i>Allocasuarina torulosa</i> , <i>E. siderophloia</i> , <i>E. crebra</i> , <i>Angophora subvelutina</i> , <i>E. tindaliae</i> and <i>Banksia integrifolia</i> . <i>Xanthorrhoea johnsonii</i> prominent in understorey. Patches of <i>Leptospermum</i> spp. Shrubland occur in places. Occurs on serpentinite. (BVG1M: 9h)	High
12.11.16	<i>Eucalyptus cloeziana</i> +/- <i>E. propinqua</i> , <i>E. acmenoides</i> , <i>E. microcorys</i> and <i>E. grandis</i> open forest. Understorey 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 Beds. (BVG1M: 8b)	Low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
12.11.17	<i>Eucalyptus acmenoides</i> or <i>E. portuensis</i> , <i>Corymbia trachyphloia</i> open forest to woodland +/- <i>E. crebra</i> , <i>Angophora leiocarpa</i> , <i>E. exserta</i> , <i>C. intermedia</i> , <i>Lophostemon confertus</i> (whipstick form). Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 9h)	Low
12.11.18	<i>Eucalyptus moluccana</i> woodland +/- <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>E. tereticornis</i> , <i>E. siderophloia</i> or <i>E. crebra</i> , <i>E. longirostrata</i> , <i>C. intermedia</i> , <i>E. carnea</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. Occurs as scattered occurrences in a range of topographic positions from ridgetops to lower slopes. (BVG1M: 13d)	High
12.11.18a	<i>Eucalyptus moluccana</i> , <i>Eucalyptus tereticornis</i> and <i>Lophostemon confertus</i> open forest. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 13d)	Medium
12.11.22	<i>Angophora leiocarpa</i> , <i>Eucalyptus crebra</i> +/- <i>Corymbia intermedia</i> , <i>E. longirostrata</i> , <i>E. major</i> , <i>E. portuensis</i> , <i>C. citriodora</i> subsp. <i>variegata</i> woodland to open forest. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 9h)	High
12.11.23	<i>Eucalyptus pilularis</i> open forest. Other canopy species include <i>E. microcorys</i> , <i>Corymbia intermedia</i> , <i>Angophora woodsiana</i> , <i>E. tindaliae</i> and <i>E. carnea</i> . <i>E. racemosa</i> subsp. <i>racemosa</i> and <i>Corymbia trachyphloia</i> are prominent in the Venman area whilst <i>C. gummifera</i> and <i>E. resinifera</i> are prominent in the Nerang area. Occurs on low coastal Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics (Nerangleigh-Fernvale beds). (BVG1M: 8b)	High
12.11.24	<i>Eucalyptus carnea</i> , <i>E. tindaliae</i> , <i>Corymbia intermedia</i> woodland +/- <i>E. crebra</i> or <i>E. siderophloia</i> , <i>Eucalyptus resinifera</i> , <i>Eucalyptus major</i> , <i>E. helidonica</i> , <i>Angophora woodsiana</i> , <i>C. trachyphloia</i> , <i>E. microcorys</i> , <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>C. henryi</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics usually at altitudes <300 metres. (BVG1M: 9g)	Medium
12.11.25	<i>Corymbia henryi</i> and/or <i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i> woodland. Other frequently occurring canopy species may include <i>Eucalyptus crebra</i> , <i>E. carnea</i> , <i>E. tindaliae</i> , <i>E. siderophloia</i> , <i>C. citriodora</i> subsp. <i>variegata</i> , <i>Angophora leiocarpa</i> , <i>E. acmenoides</i> , <i>E. helidonica</i> , <i>E. propinqua</i> , <i>C. intermedia</i> and <i>E. seeana</i> . Rarely includes patches of <i>E. dura</i> . Usually occurs on low hills, hills and footslopes of mountains in near coastal areas on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 10b)	Medium
12.11.26	<i>Eucalyptus baileyana</i> and/or <i>E. planchoniana</i> woodland to open forest. Frequently associated canopy species include <i>E. tindaliae</i> and <i>Angophora woodsiana</i> . Other associated canopy species include <i>Corymbia intermedia</i> , <i>C. trachyphloia</i> , <i>E. carnea</i> , <i>E. helidonica</i> and <i>E. resinifera</i> . Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics typically on ridges and crests. (BVG1M: 9h)	Medium
12.11.27	<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> and/or <i>E. seeana</i> and <i>Corymbia intermedia</i> woodland. Other characteristic species include <i>E. siderophloia</i> , <i>Angophora leiocarpa</i> , <i>C. trachyphloia</i> subsp. <i>trachyphloia</i> and rarely <i>E. pilularis</i> . <i>Melaleuca quinquenervia</i> may be present and at times becomes locally co-dominant. Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics, typically at low altitude (<60 metres) in near coastal situations. (BVG1M: 9g)	Medium
12.11.28	<i>Eucalyptus helidonica</i> , <i>Angophora woodsiana</i> , <i>Corymbia gummifera</i> woodland with a heathy shrub layer dominated by <i>Leptospermum trinervium</i> , <i>Xanthorrhoea johnsonii</i> and <i>Banksia spinulosa</i> var. <i>collina</i> . Other commonly occurring canopy species include <i>Eucalyptus tindaliae</i> , <i>E. carnea</i> , <i>E. resinifera</i> , <i>Corymbia intermedia</i> , <i>C. trachyphloia</i> subsp. <i>trachyphloia</i> and <i>Lophostemon confertus</i> . Occurs on crests and upper slopes of hills comprised of Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 9h)	Low
12.12.1	Notophyll and notophyll/microphyll vine forest, sometimes with <i>Archontophoenix cunninghamiana</i> and/or <i>Lophostemon confertus</i> closed forest. The plant families Lauraceae, Myrtaceae and Elaeocarpaceae are diagnostic of the type and <i>Pleioluma queenslandica</i> is common in the northern half of the bioregion. <i>Araucaria cunninghamii</i> is often present on margins. Occurs in gullies on Mesozoic to Proterozoic igneous rocks especially granite and rhyolite. (BVG1M: 4a)	Very low
12.12.2	<i>Eucalyptus pilularis</i> tall open forest with shrubby understorey. Other canopy species include <i>Syncarpia verecunda</i> , <i>Angophora woodsiana</i> , <i>Eucalyptus microcorys</i> , <i>E. resinifera</i> , <i>E. tindaliae</i> , <i>E. propinqua</i> and	Medium

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	<i>E. saligna</i> . Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 8b)	
12.12.2a	<i>Eucalyptus grandis</i> , <i>E. tereticornis</i> open forest. Occurs in gullies on Mesozoic to Proterozoic igneous rocks. (BVG1M: 8a)	Medium
12.12.2b	<i>Eucalyptus saligna</i> subsp. <i>saligna</i> open forest. Occurs on high altitude Mesozoic to Proterozoic igneous rocks. (BVG1M: 8a)	Low
12.12.3	Open forest complex in which spotted gum is a relatively common species. Canopy trees include <i>Corymbia citriodora</i> subsp. <i>variegata</i> , <i>Eucalyptus crebra</i> (drier sub coastal ranges) or <i>Eucalyptus siderophloia</i> , <i>E. major</i> and/or <i>E. longirostrata</i> , <i>E. acmenoides</i> or <i>E. portuensis</i> , <i>E. eugenioides</i> . Hills and ranges. Other species that may be present locally include <i>Corymbia intermedia</i> , <i>C. trachyphloia</i> , <i>Eucalyptus tereticornis</i> , <i>E. propinqua</i> , <i>E. moluccana</i> , <i>E. decolor</i> , <i>E. melliodora</i> , <i>E. carnea</i> , <i>E. fibrosa</i> subsp. <i>fibrosa</i> and <i>Angophora leiocarpa</i> . <i>Lophostemon confertus</i> (tree form and whipstick form) often present in gullies or as a sub-canopy or canopy tree especially on granite. Mixed understorey of grasses, shrubs and ferns. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 10b)	Medium
12.12.3a	<i>Lophostemon confertus</i> open forest. Occurs in moister gullies on Mesozoic to Proterozoic igneous rocks. (BVG1M: 8a)	Low
12.12.5	Open forest to woodland of <i>Corymbia citriodora</i> subsp. <i>variegata</i> , usually with <i>Eucalyptus crebra</i> . Other species such as <i>Eucalyptus exserta</i> , <i>E. moluccana</i> present in scattered patches or in low densities. Understorey generally grassy. Occurs on hills and ranges on Mesozoic to Proterozoic igneous rocks. (BVG1M: 10b)	Low
12.12.6	<i>Eucalyptus montivaga</i> open forest to woodland. Other canopy species can include <i>Eucalyptus acmenoides</i> , <i>Corymbia trachyphloia</i> , <i>C. gummifera</i> , <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> and <i>C. intermedia</i> . Occurs on Mesozoic to Proterozoic igneous rocks. Altitude >500 m. (BVG1M: 8b)	Low
12.12.7	<i>Eucalyptus crebra</i> grassy woodland. Other species such as <i>Corymbia erythrophloia</i> , <i>Eucalyptus exserta</i> , <i>E. tereticornis</i> , <i>C. tessellaris</i> , <i>C. citriodora</i> subsp. <i>variegata</i> may be present in low densities or in patches. Mid-layer generally sparse but can include low trees such as <i>Vachellia bidwillii</i> , <i>Alphitonia excelsa</i> , <i>Allocasuarina luehmannii</i> and <i>Petalostigma pubescens</i> . Small areas of <i>Callitris glaucophylla</i> occur in central western parts of bioregion. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 13c)	Medium
12.12.8	<i>Eucalyptus melanophloia</i> , usually with <i>E. crebra</i> +/- <i>Corymbia erythrophloia</i> grassy woodland. Other species such as <i>Eucalyptus exserta</i> , <i>E. tereticornis</i> , <i>C. tessellaris</i> , <i>C. citriodora</i> subsp. <i>variegata</i> may be present in low densities or in patches. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 17b)	Low
12.12.9	<i>Eucalyptus dura</i> woodland (open woodland in rocky areas) +/- <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> , <i>E. acmenoides</i> or <i>E. portuensis</i> , <i>Acacia blakei</i> subsp. <i>blakei</i> , <i>Allocasuarina littoralis</i> , <i>C. intermedia</i> . <i>Eucalyptus montivaga</i> may also be present at higher altitudes. <i>Lophostemon confertus</i> (whipstick form) often present in shrub layer. Usually occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 12a)	Medium
12.12.10	Shrubland or heath sometimes with emergent <i>Eucalyptus acmenoides</i> . Associated with rocky soils derived from Mesozoic to Proterozoic igneous rocks. (BVG1M: 29b)	Non-habitat
12.12.11	<i>Eucalyptus portuensis</i> or <i>E. acmenoides</i> , <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> woodland +/- <i>E. crebra</i> , <i>C. intermedia</i> , <i>E. exserta</i> and <i>Angophora leiocarpa</i> . Whipstick <i>Lophostemon confertus</i> often present in understorey and in gullies. Occurs on hillsides on Mesozoic to Proterozoic igneous rocks. (BVG1M: 9h)	Low
12.12.12	<i>Eucalyptus tereticornis</i> , <i>Corymbia intermedia</i> , <i>E. crebra</i> open forest to woodland. Other species present can include <i>Eucalyptus melanophloia</i> , <i>Corymbia tessellaris</i> , <i>Angophora subvelutina</i> , <i>A. leiocarpa</i> , <i>C. clarksoniana</i> (central and northern parts) and <i>E. siderophloia</i> with <i>Melaleuca quinquenervia</i> , <i>Lophostemon suaveolens</i> near drainage lines in moister areas. Occurs on Mesozoic to Proterozoic igneous rocks usually on lower slopes, especially granite lowlands and basins. (BVG1M: 9g)	Medium
12.12.13	Microphyll and microphyll/notophyll vine forest +/- <i>Araucaria cunninghamii</i> . Characteristic species include <i>Dendrocnide photinophylla</i> , <i>Diospyros geminata</i> , <i>Drypetes deplanchei</i> , <i>Ficus virens</i> , <i>Cryptocarya bidwillii</i> , <i>Planchonella myrsinifolia</i> , <i>Vitex lignum-vitae</i> , <i>Hernandia bivalvis</i> , <i>Croton acronychioides</i> , <i>Flindersia</i> spp. <i>Olea paniculata</i> , <i>Excoecaria dallachyana</i> , <i>Gossia bidwillii</i> and on northern half of bioregion <i>Vitex acuminata</i> , <i>Archidendropsis thozetiana</i> , <i>Pleiogynium timorense</i> and <i>Cupaniopsis</i>	Very low

Regional ecosystem	Description (Queensland Herbarium version 11 December 2018)	RE rank
	simulata. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 2a)	
12.12.14	Woodland to open forest characterised by <i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> , <i>Angophora woodsiana</i> , <i>Corymbia gummifera</i> , <i>Syncarpia</i> spp., <i>Eucalyptus helidonica</i> or <i>E. acmenoides</i> and <i>Lophostemon confertus</i> . Other canopy species include <i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i> , <i>E. carnea</i> , <i>E. tindaliae</i> , <i>E. exserta</i> , <i>E. resinifera</i> and <i>E. microcorys</i> . Usually occurs on rocky near coastal areas on Mesozoic to Proterozoic igneous rocks. (BVG1M: 9g)	Medium
12.12.15	<i>Corymbia intermedia</i> +/- <i>Eucalyptus propinqua</i> , <i>E. siderophloia</i> , <i>E. microcorys</i> , <i>Lophostemon confertus</i> . Other canopy species include <i>E. acmenoides</i> , <i>E. moluccana</i> , <i>Angophora subvelutina</i> and occasional vine forest species. Patches of <i>Eucalyptus pilularis</i> sometimes present. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 9a)	Medium
12.12.15a	<i>Eucalyptus grandis</i> and/or <i>E. saligna</i> tall open forest +/- vine forest understorey. Other canopy species include <i>E. microcorys</i> , <i>E. acmenoides</i> , <i>Lophostemon confertus</i> , <i>E. siderophloia</i> , <i>E. propinqua</i> , <i>Corymbia intermedia</i> . Occurs in wet gullies on Mesozoic to Proterozoic igneous rocks. (BVG1M: 8a)	Medium
12.12.15b	<i>Lophostemon confertus</i> open forest +/- <i>Eucalyptus microcorys</i> , <i>E. siderophloia</i> , <i>E. carnea</i> , <i>E. propinqua</i> and vine forest species often present in understorey. Occurs in gullies and exposed ridges on Mesozoic to Proterozoic igneous rocks often amongst vine forest. (BVG1M: 8a)	Medium
12.12.16	Notophyll vine forest. Characteristic species include <i>Araucaria bidwillii</i> , <i>A. cunninghamii</i> , <i>Argyrodendron trifoliolatum</i> , <i>Argyrodendron</i> sp. (Kin W.D.Francis AQ81198), <i>Backhousia subargentea</i> , <i>Brachychiton discolor</i> , <i>Beilschmiedia obtusifolia</i> , <i>Diospyros pentamera</i> , <i>Grevillea robusta</i> , <i>Gmelina leichhardtii</i> , <i>Ficus macrophylla</i> forma <i>macrophylla</i> and <i>Sloanea woollsi</i> . <i>Eucalyptus</i> spp. especially <i>E. siderophloia</i> , <i>E. propinqua</i> and <i>E. grandis</i> may be present as emergents. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 2a)	Very low
12.12.17	Low microphyll vine forest +/- <i>Araucaria cunninghamii</i> and semi-evergreen vine thicket. Characteristic species include <i>Brachychiton rupestris</i> , <i>Flindersia collina</i> , <i>F. australis</i> , <i>Alectryon diversifolius</i> , <i>A. subdentatus</i> , <i>Elatostachys xylocarpa</i> , <i>Erythroxylum</i> sp. (Splityard Creek L.Pedley 5360), <i>Psyrax odorata</i> forma <i>buxifolia</i> , <i>Diospyros geminata</i> , <i>Planchonella cotinifolia</i> , <i>Croton insularis</i> , <i>Bridelia exaltata</i> and <i>Bursaria incana</i> . <i>Melaleuca bracteata</i> is often present along watercourses. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 7a)	Very low
12.12.19	Vegetation complex of exposed rocky headlands. Vegetation types include <i>Themeda triandra</i> grassland and wind-sheared shrubland and woodland. Occurs on Mesozoic to Proterozoic igneous headlands. (BVG1M: 29a)	Non-habitat
12.12.19x2	Vegetation complex of exposed rocky headlands. Vegetation types include <i>Themeda triandra</i> grassland and wind-sheared shrubland and woodland. Occurs on headlands of Cainozoic and Mesozoic sediments. (BVG1M: 29a)	Non-habitat
12.12.19x3	Vegetation complex of exposed headlands. Vegetation types include <i>Themeda triandra</i> grassland and wind-sheared shrubland and woodland. Occurs on headlands of remnant Tertiary surfaces. (BVG1M: 29a)	Non-habitat
12.12.23	Woodland to open forest generally with <i>Eucalyptus tereticornis</i> subsp. <i>tereticornis</i> or <i>E. tereticornis</i> subsp. <i>basaltica</i> +/- <i>E. eugenioides</i> . Other species present vary from place to place but commonly include <i>E. crebra</i> , <i>Corymbia intermedia</i> , <i>E. acmenoides</i> , <i>E. biturbinata</i> , <i>E. longirostrata</i> , <i>E. melliodora</i> , <i>C. trachyphloia</i> , <i>C. citriodora</i> subsp. <i>Variegata</i> , <i>Lophostemon confertus</i> (tree form and whipstick form), <i>Angophora subvelutina</i> and <i>Allocasuarina torulosa</i> . Occurs at higher altitudes on crests, upper slopes and elevated valleys and plains on Mesozoic to Proterozoic igneous rocks. (BVG1M: 9g)	Medium
12.12.24	<i>Angophora leiocarpa</i> , <i>Eucalyptus crebra</i> +/- <i>Corymbia intermedia</i> , <i>E. longirostrata</i> , <i>E. major</i> , <i>E. tereticornis</i> , <i>E. acmenoides</i> or <i>E. portuensis</i> , <i>C. citriodora</i> subsp. <i>variegata</i> woodland to open forest. Occurs on Mesozoic to Proterozoic igneous rocks including granite. (BVG1M: 9h)	Medium
12.12.25	<i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i> woodland +/- <i>Corymbia citriodora</i> subsp. <i>Variegata</i> , <i>Angophora leiocarpa</i> , <i>E. acmenoides</i> , <i>E. decorticans</i> , <i>C. trachyphloia</i> and <i>C. watsoniana</i> in central western part of bioregion. Occurs on Mesozoic to Proterozoic igneous rocks. (BVG1M: 9h)	Low
12.12.28	<i>Eucalyptus moluccana</i> +/- <i>E. crebra</i> , <i>Corymbia citriodora</i> subsp. <i>variegata</i> woodland to open forest. Occurs on broad ridges and lower slopes on Mesozoic to Proterozoic igneous rocks. (BVG1M: 13d)	Medium

Appendix 4. Tree species utility for koalas

Tree species utility classes indicating the usefulness of trees for koalas in SEQ (REDD v10, Queensland Herbarium, 2016).

Tree species	Species utility	Source
<i>Acacia blakei</i> subsp. <i>blakei</i>	none or unknown	
<i>Acacia disparrima</i> subsp. <i>disparrima</i>	none or unknown	
<i>Acacia excelsa</i>	none or unknown	
<i>Acacia harpophylla</i>	none or unknown	
<i>Acacia leiocalyx</i>	none or unknown	
<i>Acacia pendula</i>	none or unknown	
<i>Acacia salicina</i>	none or unknown	
<i>Acacia</i> spp.	none or unknown	
<i>Acacia stenophylla</i>	none or unknown	
<i>Acacia tephрина</i>	Lower	Melzer et al. (2014)
<i>Acalypha eremorum</i>	none or unknown	
<i>Acmena ingens</i>	none or unknown	
<i>Acmena smithii</i>	none or unknown	
<i>Acronychia imperforata</i>	none or unknown	
<i>Acronychia</i> spp.	none or unknown	
<i>Agathis robusta</i>	none or unknown	
<i>Alangium villosum</i> subsp. <i>tomentosum</i>	none or unknown	
<i>Alchornea ilicifolia</i>	none or unknown	
<i>Alectryon subdentatus</i>	none or unknown	
<i>Alectryon connatus</i>	none or unknown	
<i>Alectryon coriaceus</i>	none or unknown	
<i>Alectryon diversifolius</i>	none or unknown	
<i>Alectryon oleifolius</i>	none or unknown	
<i>Alectryon subdentatus</i>	none or unknown	
<i>Allocasuarina littoralis</i>	Lower	Callaghan et al. (2011)
<i>Allocasuarina luehmannii</i>	none or unknown	
<i>Allocasuarina torulosa</i>	Lower	Callaghan et al. (2011), and cited in Smith (2004) (northern NSW study however)
<i>Alphitonia excelsa</i>	none or unknown	
<i>Angophora floribunda</i>	Lower	
<i>Angophora leiocarpa</i>	Lower	
<i>Angophora</i> spp.	Lower	
<i>Angophora subvelutina</i>	Lower	
<i>Angophora woodsiana</i>	Lower	
<i>Aphananthe philippinensis</i>	none or unknown	
<i>Araucaria bidwillii</i>	none or unknown	
<i>Araucaria cunninghamii</i>	none or unknown	
<i>Archidendropsis thozetiana</i>	none or unknown	
<i>Archontophoenix alexandrae</i>	none or unknown	
<i>Archontophoenix cunninghamiana</i>	none or unknown	
<i>Argyrodendron actinophyllum</i>	none or unknown	
<i>Argyrodendron</i> sp. (Kin W.D.Francis AQ81198)	none or unknown	
<i>Argyrodendron trifoliolatum</i>	none or unknown	
<i>Arytera divaricata</i>	none or unknown	
<i>Backhousia myrtifolia</i>	none or unknown	
<i>Backhousia subargentea</i>	none or unknown	
<i>Baloghia inophylla</i>	none or unknown	
<i>Banksia aemula</i>	none or unknown	
<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	none or unknown	
<i>Banksia oblongifolia</i>	none or unknown	
<i>Banksia robur</i>	none or unknown	

Tree species	Species utility	Source
<i>Banksia spinulosa</i> var. <i>collina</i>	none or unknown	
<i>Baumea juncea</i>	none or unknown	
<i>Beilschmiedia obtusifolia</i>	none or unknown	
<i>Boronia falcifolia</i>	none or unknown	
<i>Brachychiton acerifolius</i>	none or unknown	
<i>Brachychiton discolor</i>	none or unknown	
<i>Brachychiton populneus</i>	none or unknown	
<i>Brachychiton rupestris</i>	none or unknown	
<i>Bridelia exaltata</i>	none or unknown	
<i>Bridelia leichhardtii</i>	none or unknown	
<i>Bursaria incana</i>	none or unknown	
<i>Caldcluvia paniculosa</i>	none or unknown	
<i>Callitris baileyi</i>	none or unknown	
<i>Callitris columellaris</i>	Lower	Callaghan et al. (2011); Woodward (2008) (day time use)
<i>Callitris glaucophylla</i>	none or unknown	
<i>Capparis arborea</i>	none or unknown	
<i>Cassia brewsteri</i>	none or unknown	
<i>Castanospermum australe</i>	none or unknown	
<i>Casuarina cristata</i>	none or unknown	
<i>Casuarina cunninghamiana</i>	none or unknown	
<i>Casuarina cunninghamiana</i> subsp. <i>cunninghamiana</i>	none or unknown	
<i>Casuarina equisetifolia</i> subsp. <i>incana</i>	none or unknown	
<i>Casuarina glauca</i>	none or unknown	
<i>Ceratopetalum apetalum</i>	none or unknown	
<i>Citronella moorei</i>	none or unknown	
<i>Citrus glauca</i>	none or unknown	
<i>Coatesia paniculata</i>	none or unknown	
<i>Corymbia citriodora</i>	Medium	Melzer et al. (2014); Thompson (2006); EPA (2004); Lone Pine; EHP factsheet; Mogridge
<i>Corymbia citriodora</i> subsp. <i>variegata</i>	Medium	Thompson (2006); Lone Pine; Mogridge
<i>Corymbia clarksoniana</i>	Lower	
<i>Corymbia dallachiana</i>	Lower	Melzer et al. (2014)
<i>Corymbia erythrophloia</i>	Lower	Melzer et al. (2014)
<i>Corymbia gummifera</i>	Lower	
<i>Corymbia henryi</i>	Medium	EPA (2004)
<i>Corymbia intermedia</i>	Medium	Callaghan et al. (2011); EHP factsheet; LWA factsheet
<i>Corymbia tessellaris</i>	Lower	Melzer et al. (2014)
<i>Corymbia trachyphloia</i>	Lower	
<i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i>	Lower	
<i>Corymbia watsoniana</i>	Lower	
<i>Croton acronychioides</i>	none or unknown	
<i>Croton insularis</i>	none or unknown	
<i>Cryptocarya bidwillii</i>	none or unknown	
<i>Cryptocarya erythroxylon</i>	none or unknown	
<i>Cryptocarya microneura</i>	none or unknown	
<i>Cryptocarya obovata</i>	none or unknown	
<i>Cryptocarya triplinervis</i>	none or unknown	
<i>Cupaniopsis anacardioides</i>	none or unknown	
<i>Cupaniopsis parvifolia</i>	none or unknown	
<i>Cupaniopsis simulata</i>	none or unknown	
<i>Dendrocnide excelsa</i>	none or unknown	
<i>Dendrocnide photinophylla</i>	none or unknown	
<i>Denhamia oleaster</i>	none or unknown	
<i>Denhamia pittosporoides</i>	none or unknown	
<i>Diospyros fasciculosa</i>	none or unknown	
<i>Diospyros geminata</i>	Lower	Melzer unpublished
<i>Diospyros humilis</i>	none or unknown	

Tree species	Species utility	Source
<i>Diospyros pentamera</i>	none or unknown	
<i>Diospyros</i> spp.	none or unknown	
<i>Diploglottis australis</i>	none or unknown	
<i>Dissiliaria baloghioides</i>	none or unknown	
<i>Doryphora sassafras</i>	none or unknown	
<i>Drypetes deplanchei</i>	none or unknown	
<i>Dysoxylum fraserianum</i>	none or unknown	
<i>Dysoxylum mollissimum</i> subsp. <i>molle</i>	none or unknown	
<i>Elaeocarpus grandis</i>	none or unknown	
<i>Elaeocarpus kirtonii</i>	none or unknown	
<i>Elaeocarpus obovatus</i>	none or unknown	
<i>Elattostachys xylocarpa</i>	none or unknown	
<i>Endiandra pubens</i>	none or unknown	
<i>Endiandra sieberi</i>	Lower	Callaghan et al. (2011)
<i>Eremophila mitchellii</i>	none or unknown	
<i>Erythroxylum</i> sp. (Splityard Creek L.Pedley 5360)	none or unknown	
<i>Eucalyptus acmenoides</i>	Medium	EPA (2004); Rhodes et al. (2015); AKF
<i>Eucalyptus albens</i>	Lower	
<i>Eucalyptus baileyana</i>	Lower	
<i>Eucalyptus bancroftii</i>	Medium	EPA (2004); Mogridge; AKF
<i>Eucalyptus banksii</i>	Lower	
<i>Eucalyptus biturbinata</i>	Higher	EPA (2004); Lone Pine; Mogridge and based on similarity to <i>Eucalyptus propinqua</i>
<i>Eucalyptus brownii</i>	Medium	Based on similarity to <i>Eucalyptus populnea</i> , highly unlikely to occur in the study area.
<i>Eucalyptus camaldulensis</i>	Higher	Wu et al. (2012); Lone Pine; Mogridge; LWA factsheet
<i>Eucalyptus cambageana</i>	Lower	Melzer et al. (2014)
<i>Eucalyptus campanulata</i>	Lower	
<i>Eucalyptus carnea</i>	Medium	EPA (2004); EHP factsheet
<i>Eucalyptus cloeziana</i>	Lower	
<i>Eucalyptus coolabah</i>	Medium	Wu et al. (2012); FitzGibbon et al. (2013) (central Queensland)
<i>Eucalyptus crebra</i>	Medium	Melzer et al. (2014); EPA (2004); Hasegawa (1995); FitzGibbon et al. (2013) (central Queensland); LWA factsheet
<i>Eucalyptus decolor</i>	Lower	
<i>Eucalyptus decorticans</i>	Lower	
<i>Eucalyptus drepanophylla</i>	Medium	Melzer et al. (2014)
<i>Eucalyptus dunni</i>	Medium	Lone Pine; Mogridge; LWA factsheet
<i>Eucalyptus dura</i>	Lower	
<i>Eucalyptus eugenioides</i>	Medium	listed in McFarland profile - Habitat Suitability Modelling for South East Queensland
<i>Eucalyptus exserta</i>	Medium	Mogridge; Melzer recommended
<i>Eucalyptus fibrosa</i> subsp. <i>fibrosa</i>	Medium	Thompson (2006); EPA (2004); EHP factsheet
<i>Eucalyptus grandis</i>	Medium	Lone Pine; Mogridge; AKF; LWA factsheet
<i>Eucalyptus helidonica</i>	Medium	Based on inference from similar species to <i>Eucalyptus acmenoides</i>
<i>Eucalyptus interstans</i>	Lower	
<i>Eucalyptus laevopinea</i>	Lower	
<i>Eucalyptus latisinensis</i>	Medium	Based on inference from similar species to <i>Eucalyptus acmenoides</i>
<i>Eucalyptus longirostrata</i>	Higher	Mogridge, based on similarity to <i>Eucalyptus propinqua</i>
<i>Eucalyptus major</i>	Higher	EHP factsheet; Mogridge, based on similarity to <i>Eucalyptus propinqua</i> ; LWA factsheet
<i>Eucalyptus melanoleuca</i>	Lower	
<i>Eucalyptus melanophloia</i>	Medium	EPA (2004)
<i>Eucalyptus melliodora</i>	Lower	
<i>Eucalyptus microcarpa</i>	Medium	Based on inference from similar species to <i>Eucalyptus moluccana</i>
<i>Eucalyptus microcorys</i>	Higher	Thompson (2006); Callaghan et al. (2011); EPA (2004); Lone Pine; EHP factsheet; Mogridge; Rhodes et al. (2015); AKF; LWA factsheet

Tree species	Species utility	Source
<i>Eucalyptus moluccana</i>	Medium	EPA (2004); Lone Pine; EHP factsheet; Mogridge; LWA factsheet
<i>Eucalyptus montivaga</i>	Medium	Based on inference from similar species to <i>Eucalyptus acmenoides</i>
<i>Eucalyptus nobilis</i>	Lower	
<i>Eucalyptus obliqua</i>	Lower	
<i>Eucalyptus oreades</i>	Lower	
<i>Eucalyptus orgadophila</i>	Medium	Melzer et al. (2014)
<i>Eucalyptus pilularis</i>	Medium	Melzer et al. (2014); Woodward et al. (2008); LWA factsheet
<i>Eucalyptus planchoniana</i>	Lower	Melzer et al. (2014)
<i>Eucalyptus platyphylla</i>	Medium	Melzer recommended
<i>Eucalyptus populnea</i>	Medium	Melzer et al. (2014); Wu et al. (2012); Mogridge; FitzGibbon et al. (2013) (central Queensland)
<i>Eucalyptus portuensis</i>	Medium	Based on inference from similar species to <i>Eucalyptus acmenoides</i>
<i>Eucalyptus propinqua</i>	Higher	Callaghan et al. (2011); EPA (2004); Lone Pine; EHP factsheet; Mogridge; Rhodes et al. (2015); AKF; LWA factsheet
<i>Eucalyptus psammitica</i>	Lower	
<i>Eucalyptus racemosa</i>	Medium	Thompson (2006); Melzer et al. (2014); EPA (2004); Lone Pine; EHP factsheet; Mogridge; AKF; LWA factsheet
<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i>	Medium	based on inference from base species
<i>Eucalyptus resinifera</i>	Medium	Thompson (2006); Callaghan et al. (2011); AKF; Melzer et al. (2014); Woodward et al. (2008); EPA (2004); Lone Pine; EHP factsheet; LWA factsheet
<i>Eucalyptus robusta</i>	Higher	Callaghan et al. (2011); Melzer et al. (2014); Woodward et al. (2008); EPA (2004); Lone Pine; EHP factsheet; Mogridge; LWA factsheet; AKF
<i>Eucalyptus saligna</i>	Medium	LWA factsheet and based on similarity to <i>Eucalyptus grandis</i>
<i>Eucalyptus saligna</i> subsp. <i>saligna</i>	Medium	LWA factsheet and based on similarity to <i>Eucalyptus grandis</i>
<i>Eucalyptus seeana</i>	Medium	EPA (2004); EHP factsheet; Mogridge; LWA factsheet; Brisbane City Council recommended feed tree
<i>Eucalyptus siderophloia</i>	Medium	Callaghan et al. (2011); EPA (2004); EHP factsheet; AKF; LWA factsheet
<i>Eucalyptus sideroxylon</i>	Medium	Mogridge
<i>Eucalyptus taurina</i>	Lower	
<i>Eucalyptus tereticornis</i>	Higher	Callaghan et al. (2011); Melzer et al. (2014); Woodward et al. (2008); Pfeiffer et al. (2005); EPA (2004); Lone Pine; EHP factsheet; Mogridge; AKF; LWA factsheet
<i>Eucalyptus tereticornis</i> subsp. <i>tereticornis</i>	Higher	based on inference from base species
<i>Eucalyptus tereticornis</i> subsp. <i>basaltica</i>	Higher	based on inference from base species
<i>Eucalyptus tindaliae</i>	Medium	Thompson (2006); EHP factsheet; Melzer et al. (2014)
<i>Eucalyptus whitei</i>	Lower	Melzer et al. (2014)
<i>Eucalyptus woollsiana</i>	Lower	
<i>Excoecaria dallachyana</i>	none or unknown	
<i>Exocarpos latifolius</i>	none or unknown	
<i>Ficus coronata</i>	none or unknown	
<i>Ficus macrophylla</i> forma <i>macrophylla</i>	none or unknown	
<i>Ficus rubiginosa</i>	none or unknown	
<i>Ficus virens</i>	none or unknown	
<i>Ficus watkinsiana</i>	none or unknown	
<i>Flindersia australis</i>	none or unknown	
<i>Flindersia collina</i>	none or unknown	
<i>Flindersia dissosperma</i>	none or unknown	
<i>Flindersia schottiana</i>	none or unknown	
<i>Flindersia</i> spp.	none or unknown	
<i>Flindersia xanthoxyla</i>	none or unknown	
<i>Geijera parviflora</i>	none or unknown	
<i>Glochidion sumatranum</i>	none or unknown	
<i>Gmelina leichhardtii</i>	none or unknown	
<i>Gossia bidwillii</i>	none or unknown	
<i>Grevillea banksii</i>	none or unknown	
<i>Grevillea robusta</i>	none or unknown	

Tree species	Species utility	Source
<i>Hakea actites</i>	none or unknown	
<i>Hernandia bivalvis</i>	none or unknown	
<i>Hodgkinsonia ovatiflora</i>	none or unknown	
<i>Jagera pseudorhus</i>	none or unknown	
<i>Karrabina benthamiana</i>	none or unknown	
<i>Leptospermum</i> spp.	none or unknown	
<i>Leptospermum trinervium</i>	none or unknown	
<i>Livistona australis</i>	none or unknown	
<i>Livistona decora</i>	none or unknown	
<i>Livistona</i> spp.	none or unknown	
<i>Lophostemon confertus</i>	Medium	EHP factsheet; Mogridge; LWA factsheet
<i>Lophostemon suaveolens</i>	lower	McFarland profile
<i>Lysicarpus angustifolius</i>	none or unknown	
<i>Lysiphyllum carronii</i>	none or unknown	
<i>Lysiphyllum</i> spp.	none or unknown	
<i>Macadamia</i> spp.	none or unknown	
<i>Macropteranthes leichhardtii</i>	none or unknown	
<i>Mallotus discolor</i>	none or unknown	
<i>Mallotus philippensis</i>	none or unknown	
<i>Melaleuca bracteata</i>	Lower	Melzer et al. (2014)
<i>Melaleuca cheelii</i>	none or unknown	
<i>Melaleuca dealbata</i>	none or unknown	
<i>Melaleuca fluvialis</i>	none or unknown	
<i>Melaleuca irbyana</i>	none or unknown	
<i>Melaleuca linariifolia</i>	none or unknown	
<i>Melaleuca nervosa</i>	Lower	Melzer et al. (2014)
<i>Melaleuca nodosa</i>	none or unknown	
<i>Melaleuca quinquenervia</i>	Medium	Callaghan et al. (2011); Melzer et al. (2014); EPA (2004); EHP factsheet; LWA factsheet
<i>Melaleuca salicina</i>	none or unknown	
<i>Melaleuca sieberi</i>	none or unknown	
<i>Melaleuca</i> spp.	none or unknown	
<i>Melaleuca thymifolia</i>	none or unknown	
<i>Melaleuca trichostachya</i>	none or unknown	
<i>Melaleuca viminalis</i>	none or unknown	
<i>Melaleuca viridiflora</i> var. <i>viridiflora</i>	none or unknown	
<i>Melastoma labathricum</i> subsp. <i>malabathricum</i>	none or unknown	
<i>Melia azedarach</i>	none or unknown	
<i>Melicope elleryana</i>	none or unknown	
<i>Mischocarpus pyriformis</i> subsp. <i>pyriformis</i>	none or unknown	
<i>Muraya ovatifoliolata</i>	none or unknown	
<i>Neolitsea dealbata</i>	none or unknown	
<i>Notelaea microcarpa</i>	none or unknown	
<i>Nothofagus moorei</i>	none or unknown	
<i>Olea paniculata</i>	none or unknown	
<i>Orites excelsus</i>	none or unknown	
<i>Owenia acidula</i>	none or unknown	
<i>Pandanus tectorius</i>	none or unknown	
<i>Petalostigma pubescens</i>	none or unknown	
<i>Pittosporum angustifolium</i>	none or unknown	
<i>Pittosporum undulatum</i>	none or unknown	
<i>Planchonella australis</i>	none or unknown	
<i>Planchonella cotinifolia</i>	none or unknown	
<i>Planchonella myrsinifolia</i>	none or unknown	
<i>Planchonella pohlmiana</i>	none or unknown	
<i>Pleiogynium timorensense</i>	none or unknown	
<i>Pleioluma queenslandica</i>	none or unknown	

Tree species	Species utility	Source
<i>Pleurostylie opposita</i>	none or unknown	
<i>Podocarpus elatus</i>	none or unknown	
<i>Polyalthia nitidissima</i>	none or unknown	
<i>Pseudoweinmannia lachnocarpa</i>	none or unknown	
<i>Psydrax odorata</i>	none or unknown	
<i>Psydrax odorata</i> forma <i>buxifolia</i>	none or unknown	
<i>Rhodospaera rhodanthema</i>	none or unknown	
<i>Siphonodon australis</i>	none or unknown	
<i>Sloanea australis</i>	none or unknown	
<i>Sloanea woollsii</i>	none or unknown	
<i>Syncarpia glomulifera</i>	Lower	Callaghan et al. (2011)
<i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i>	none or unknown	
<i>Syncarpia hillii</i>	none or unknown	
<i>Syncarpia verecunda</i>	none or unknown	
<i>Synoum glandulosum</i> subsp. <i>glandulosum</i>	none or unknown	
<i>Syzygium australe</i>	none or unknown	
<i>Syzygium corynanthum</i>	none or unknown	
<i>Syzygium crebrinerve</i>	none or unknown	
<i>Syzygium francisii</i>	none or unknown	
<i>Syzygium moorei</i>	none or unknown	
<i>Toona ciliata</i>	none or unknown	
<i>Tristaniopsis laurina</i>	none or unknown	
<i>Turraea pubescens</i>	none or unknown	
<i>Vachellia bidwillii</i>	none or unknown	
<i>Vitex acuminata</i>	none or unknown	
<i>Vitex lignum-vitae</i>	none or unknown	
<i>Waterhousea floribunda</i>	none or unknown	

Species utility classes	Description
Higher	Mentioned in a broad range of reports and literature, the majority of which are definitive studies, and were described as being an important species.
Medium	Mentioned in some reports and literature, can be secondary, anecdotal e.g. included in a factsheet
Lower	Not mentioned in any literature or considered a trace food species from a definitive study, and/or eucalypt species
None or unknown	Not mentioned in any literature, and not a eucalypt

Source	Definitive or Secondary (Anecdotal/Expert derived/Factsheet)	Description
AKF	Secondary	Australian Koala Foundation - in McAlpine et al., 2007 <i>Planning guidelines for koala conservation and recovery</i> .
Callaghan et al. (2011)	Definitive	Callaghan et al. 2011. Koala habitat mapping based on tree species use. <i>Wildlife Research</i> , vol.38, pp.89-102
EHP factsheet (2012)	Secondary	EHP - Planting trees for koalas factsheet: Coastal South East Queensland
EPA (2004)	Secondary	Environmental Protection Agency (EPA). 2004. Koala Habitat Map Methodology, Version 1, released 24th May 2004. Internal report, Biodiversity Planning Division.
FitzGibbon et al. (2013)	Secondary	The Koala Venture Research Partnership: an overview of 24 years of regional koala research in central Queensland in Flint and Melzer (2013)
Hasegawa (1995)	Definitive	Cited in Callaghan et al. (2011) - Habitat usage by Koalas at Point Halloran - Master's thesis.
Lone Pine	Secondary	Lone Pine Captive koala food preferences e-mail received 04/10/16
LWA factsheet	Secondary	Land for Wildlife (LWA) Queensland :note A4
McFarland profile	Secondary	<i>Phascolarctos cinereus</i> (Koala) Profile - Habitat Suitability Modelling for South East Queensland, Regional Ecosystem Version 7, 2013
Melzer et al. (2014)	Definitive	Melzer et al. 2014. The habitat and diet of koalas (<i>Phascolarctos cinereus</i>) in Queensland. <i>Australian Mammalogy</i> , vol.36, pp.189-199.
Mogridge	Secondary	Grant Mogridge browse preference list, based on experience at two SEQ captive koala facilities (Lone Pine and Australian Woolshed) and the Cairns Tropical Zoo. Have included species where listed as >90% eaten
Pfeiffer et al. (2005)	Definitive	Pfeiffer et al. 2005. Tree use by koalas (<i>Phascolarctos cinereus</i>) on St Bees Island, Queensland – report of a pilot study. <i>Proceedings of the Royal Society of Queensland</i> , vol.112, pp.47-51.
Rhodes et al. (2015)	Secondary	Rhodes et al. 2015. South East Queensland Koala Population Modelling Study. UniQuest – internal report for EHP, Brisbane, Australia
Smith (2004)	Secondary	Cited in Callaghan et al. (2011)
Thompson 2006	Definitive but based on daytime roosting, not faecal pellet study	Thompson, JA 2006. The comparative ecology and population dynamics of koalas in the koala coast region of south-east Queensland. PhD Thesis, School of Integrative Biology, University of Queensland
Woodward et al. (2008)	Definitive	Woodward et al. 2008. Koalas on north Stradbroke Island: Diet, tree use and reconstructed landscapes. <i>Wildlife Research</i> , vol.35, pp.606-611.
Wu et al. (2012)	Definitive, however south west Queensland relevant	Wu et al. 2012. The dietary preferences of koalas, <i>Phascolarctos cinereus</i> , in southwest Queensland. <i>Australian Zoologist</i> , vol.36, pp.93-102.

Appendix 5. RE koala suitability classification example

The following provides an example of the approach used to calculate the suitability of regional ecosystems using the presence and relative dominance of tree species utilised by koalas. The information was provided to the experts to support their assessment of the importance of each RE occurring in the study area.

Regional ecosystem classification steps

In this hypothetical example the RE is a heterogeneous polygon attributed as: 12.9-10.5a/12.9-10.7 (95/5). Thus, RE 12.9-10.7 is a subdominant component comprising 5% of the polygon. The description of 12.9-10.7 is: *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland on Cainozoic and Mesozoic sediments.

Step 1: Allocating tree species utility class

- Koala tree species utility was determined for each tree species listed in the descriptions of REs present within the study area (288 species) through review of the available literature and inputs from the KAG.
- Each tree species was rated as higher, medium, lower, or none/unknown utility according to the definitions in the tree species utility table (Appendix 4).
- For RE 12.9-10.7, the following utility classes were allocated: *Eucalyptus crebra* (medium), *E. tereticornis* (higher), *Corymbia tessellaris* (lower), *Angophora leiocarpa* (lower), and *E. melanophloia* (medium).

Step 2: Regional ecosystem classification

- Classification of REs into suitability categories was based on the presence of higher, medium and lower/unknown utility species within the RE description and their level of dominance within the description i.e. whether they were dominant, co-dominant, sub-dominant, occasionally occurring (i.e. and/or) or other (i.e. may be present, described as +/-).
- Species were given a relative weighting according to the table below based on their utility value, presence and relative dominance within the RE description.

Species dominance	Higher utility tree species scoring	Medium tree species scoring	Other (lower or unknown) tree species scoring
Dominant	15	10	5
Co-dominant	14	9	4
Sub-dominant	12	8	3
Occasional (and/or)	11	7	2
Other (may be present; +/-)	6	6	1

- The presence of koala occurrence records was also considered when allocating the RE suitability category, whereby a ranking could be upgraded or downgraded based on the percentage of polygons with koala records.
- The species mix for RE 12.9-10.7 resulted in a score of 16 (6 points for having *Eucalyptus tereticornis* (a higher utility species) as may be present (+/-), and 10 points for having *Eucalyptus crebra* (a medium utility species) as dominant). In addition, 12% of polygons with this RE had a koala record.
- The final score resulted in RE 12.9-10.7 being allocated a medium RE suitability in the five class scheme according to the scoring table below.

Score	Category	Decision qualifier
0 – 1	Non-habitat	
2 – 8	Non-habitat or very low	Very low if vine thicket or rainforest
9 – 13	Low	
14 – 20	Medium	
21	High or medium	If highest score >12 then high
21+	High	

Step 3: Dealing with heterogeneous polygons

- Assigned RE suitability classes were then translated into the RE mapping units (remnant & pre-clearing).
- If a polygon was heterogeneous (i.e. consisting of a mix of RE suitability classes) it was attributed with the highest ranked RE suitability class within the polygon.

Since 12.9-10.5a was determined to have a low RE suitability and 12.9-10.7 has a medium RE suitability then the polygon was attributed with a medium RE suitability.

Appendix 6. Maxent supplementary information

Maxent modelling

The koala habitat modelling was conducted using Maximum Entropy Species Distribution Modelling software (Maxent v.3.3.3k) which is a widely used program for generating species distribution models based on presence-only species records (Elith et al. 2006, Phillips et al. 2006; Elith et al. 2011; Young et al. 2011; Yackulic et al. 2013). Maxent has gained popularity for use in species modelling due to its ability to make predictions from incomplete information, such as the common scenario where systematic survey data is not available.

Maxent (which stands for maximum entropy), is a machine learning algorithm that predicts species occurrences by finding the distribution that is most spread out, or closest to uniform (maximum entropy), while taking into account the limits of the environmental variables at known locations. Environmental functions are constructed based upon the environmental variation encountered at presence locations, while taking into account the environmental variation present across the broader study area. The environmental variation present within a study area is estimated via a large random sample of background point locations across the study area (10,000 point locations).

To develop the Maxent model the project team undertook an extensive process of compiling environmental variables (measures) on the basis of known or hypothesised links to koala habitat and ecology (Table 15). Additionally, data sources needed to be available and mapped at an appropriate resolution (scale) across the study area. The environmental measures represented indicators of terrain, soil, climate, landcover, vegetation and groundwater.

Correlations among the candidate measures and a pilot Maxent analysis were used to reduce the initial set of 18 candidate measures to a final set of 13 measures used to build the model (Table 15). Correlations were examined using the Pearson product moment and Spearman's rank correlation (Figure 23) and scatterplots (Figure 24). Some highly correlated landcover measures, such as foliage projective cover (hlfpc) and seasonal persistent green cover (hlpgc) were removed in preference for retaining NDVI (hndv). Groundwater salinity (hgsal) was removed in favour of groundwater dependent ecosystems (hgpot). Aspect (htasp) and landzones with colluvium (hvlzc) were removed because of very weak responses in the Maxent pilot. Other less strongly correlated measures were retained primarily because the objective was to produce the best possible model and the study was less interested in the coefficients of the measures (i.e. which variables had the greatest impact on model discriminatory capability) and determining the key drivers of koala habitat distribution¹⁰. In addition, measures were retained if they were of particular interest; if they had been previously been shown to be important in other koala habitat models; or if they may diverge (show lower correlation) in future climate scenarios (Adams-Hosking et al. 2011; 2012; Garden et al. 2015; Santika et al. 2015; Briscoe et al. 2016; Queensland Herbarium 2016; Law et al. 2017). Maxent is less sensitive to correlations between predictor variables (measures) than some other modelling methods because the regularisation method it uses makes it reasonably robust (Elith 2008).

The pilot Maxent analysis was conducted to examine the relative contribution of the 18 candidate variables to model performance. In a stepwise procedure, a number of model runs were undertaken to iteratively remove each explanatory measure and assess the impact on model performance. Estimates of relative contributions of the environmental measures to the model were made using Maxent's percent contribution¹¹, permutation importance¹² and built-in jackknife¹³ tests.

¹⁰ Given the potential correlations, care must be taken in interpretation of the model predictors. "If two measures were highly correlated and one made a much greater contribution to the model than the other, this does not necessarily imply that the contributing one is far more important to the species than the other. It's just that it was chosen by the model, and because it was chosen, its correlated pair was rarely selected" (Elith 2008, p44).

¹¹ While the Maxent model is being trained, it keeps track of which environmental measures are contributing to fitting the model. Each iteration of the algorithm increases the gain (goodness of fit) by modifying the coefficient (weight) for a single environmental measure. The program assigns the increase in the regularised gain to the environmental variable and at the end of the training process calculates the percent contribution (Phillips et al. 2006). The percent contribution values are only heuristically defined—being dependent on the particular path used to get to the optimal solution, and a different algorithm could get the same solution via a different path, resulting in different percent contribution values.

¹² Permutation importance depends only on the final Maxent model, not the path used to obtain it. The contribution for each measure is determined by randomly permuting the values of that variable among the training points (both presence and background) and measuring the resulting decrease in training AUC. A large decrease indicates that the model depends heavily on that measure. Values are normalized to give percentages.

¹³ In the jackknife testing Maxent creates a number of models where each measure was excluded in turn, and a model created with the remaining measures. Then a model was created using each variable in isolation and compared to a model created using all measures. The environmental variable with the highest gain when used in isolation provides the most useful information by itself. The variable that the decreases the gain the most when it is omitted indicates that it may have the most information that isn't present in the other measures (Elith et al. 2006; Phillips et al. 2006).

	htasp	hctsv	hcmil	hlndv	htrug	hgsal	hgpot	htele	hscec	htslo	hlpgr	hctem	hcapr	hswat	hspho	hlfp	hsnit	hvlzc
htasp	1.00																	
hctsv	0.01	1.00																
hcmil	-0.01	-0.82	1.00															
hlndv	-0.06	-0.43	0.59	1.00														
htrug	0.02	0.09	0.15	0.13	1.00													
hgsal	0.01	0.39	-0.36	-0.18	-0.05	1.00												
hgpot	0.02	0.40	-0.39	-0.19	-0.02	0.96	1.00											
htele	0.01	0.31	0.14	0.20	0.50	0.01	-0.01	1.00										
hscec	-0.01	0.43	-0.31	-0.23	0.17	0.06	0.03	0.32	1.00									
htslo	0.03	0.09	0.15	0.15	0.94	-0.03	-0.01	0.50	0.18	1.00								
hlpgr	0.03	-0.45	0.63	0.83	0.21	-0.20	-0.20	0.22	-0.27	0.23	1.00							
hctem	-0.02	0.61	-0.83	-0.53	-0.33	0.31	0.34	-0.55	0.07	-0.34	-0.56	1.00						
hcapr	-0.02	-0.82	0.94	0.55	0.03	-0.35	-0.40	-0.05	-0.41	0.03	0.60	-0.66	1.00					
hswat	-0.03	0.38	-0.14	-0.09	0.21	0.05	0.00	0.38	0.73	0.22	-0.12	-0.01	-0.22	1.00				
hspho	0.00	0.04	0.13	0.03	0.18	-0.11	-0.12	0.28	0.30	0.19	0.08	-0.20	0.04	0.38	1.00			
hlfp	0.06	-0.37	0.55	0.73	0.23	-0.19	-0.20	0.30	-0.25	0.24	0.85	-0.55	0.50	-0.16	0.03	1.00		
hsnit	-0.01	-0.10	0.34	0.19	0.29	-0.18	-0.22	0.40	0.32	0.29	0.22	-0.44	0.22	0.44	0.76	0.15	1.00	
hvlzc	0.01	0.32	-0.24	-0.08	0.18	0.39	0.43	0.14	0.11	0.19	0.00	0.19	-0.25	0.07	0.06	-0.05	-0.03	1.00

*Correlations greater than 0.7 or less than -0.7 shown in bold.

Figure 23: Pearson's correlation matrix

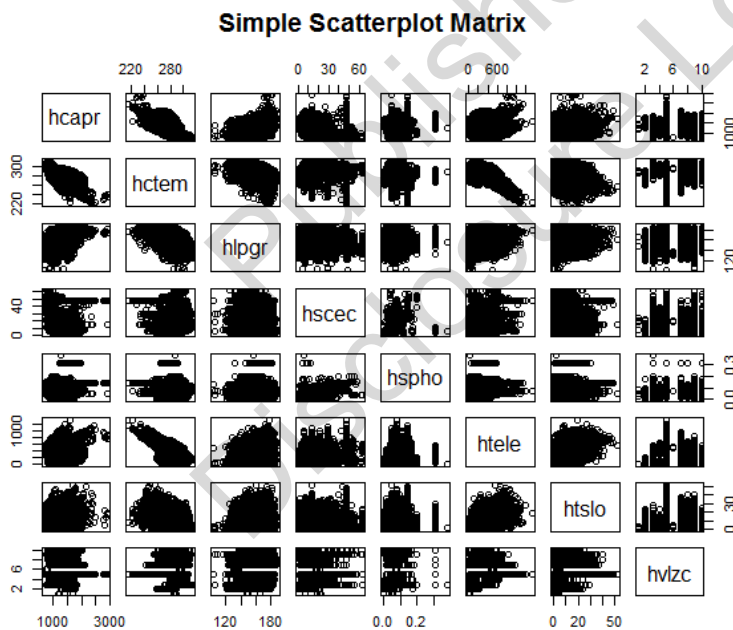


Figure 24: Scatterplot matrix.

Variables were then ranked according to their contribution and permutation importance and examined for natural breaks. Variables that either contributed the most to an increase in the AUC or those that decreased the AUC when omitted and were examined in greater detail for inclusion in the final model. Similarly measures that either contributed the most to model gain in the jackknife tests or those that decreased the gain the most when omitted,

tended to be included in the final model. Marginal response curves (partial plots) and variable response curves¹⁴ showing how koala presence varied across the range of each environmental variable were also examined to ensure they reflected expert knowledge of their ecological relationships. Measures that contributed at least 2% to the model result were retained.

A comprehensive analysis of vegetation communities and land zones was undertaken which included using the KAG to categorise and rank the regional ecosystems that occur in SEQ for their suitability to koalas and testing land zones with the inclusion of colluvium. Despite an exhaustive analysis, the contribution of vegetation communities and land zones to model predictions was weak and consequently these variables were excluded from the Maxent model. This is consistent with the work from Garden et al. (2015) who found specific floristic types did not increase modelling power. Instead, our approach was to develop a separate RE suitability classification based on expert knowledge and integrate it with the Maxent model using a decision matrix to produce the final koala habitat model. This iterative testing process resulted in the final set of 13 explanatory measures used in the Maxent model.

Training (fitting) the model was done using the remnant and non-remnant RE mapping (Queensland Herbarium, DSITI 2016, RE v10.0). Koalas predominantly utilise eucalypt trees for their food requirements although they will utilise non-eucalypt trees for other habitat requirements such as thermoregulation and shelter from fires (Briscoe et al. 2014). Consequently we created a training mask that represented all vegetation communities and included remnant and non-remnant (regrowth only) vegetation while excluding cleared areas. Eliminating koala records from cleared areas during the training process not only decreased the potential sampling bias but also reduced the potential mismatch between when the koala record was obtained and the date of any subsequent clearing and habitat loss. As koalas are a tree dependent species, using a mask that represented vegetation (with trees) prevented the model from being trained in cleared or urban areas (without trees) - thereby reducing temporal and environmental bias.

Survey bias

Two approaches of reducing bias associated with survey effort were investigated: using a bias grid reflective of human population density (Phillips et al. 2009; Elith et al. 2010; Merow et al. 2013) and spatial filtering of occurrence data (Araújo and Guisan 2006; Boria et al. 2014). A bias grid is intended to represent sampling probability (i.e. where cell values reflect sampling effort) and is used to modify the background sample data or occurrence records to cancel out impacts associated with survey effort (*sensu* Fourcade et al. 2014). In the current project, a bias grid was tested based upon a Gaussian kernel density analysis of human population density (ABS census 2011), which was then rescaled from 1 to 20, following Elith et al. (2010) and implemented in the bias file option in Maxent. Other approaches to account for bias, including down-weighting records occurring along roads (Queensland Herbarium 2015; Briscoe et al. 2016), creating a bias grid based upon known occurrences of the species, or from closely related species (Phillips et al. 2009) were not used in this study. In koala studies from New South Wales, others have used information on other commonly recorded species to estimate detection bias (Santika et al. 2014; and Law et al. 2017).

The second approach used spatial filtering to select a subsample of records in geographical space. Although Maxent discards redundant records that occur in a single cell (in our case, 1ha), we removed neighbouring occurrences at a coarser resolution by creating a hexagonal grid and randomly sampling one occurrence record per grid cell (*sensu* Fourcade et al. 2014). The grid cell size used to sample the occurrences must be large enough to resolve the bias but not too large to result in a strong loss in resolution (Fourcade et al. 2014). We evaluated the resolution of the filtering that provided the optimal trade-off between sampling bias correction and information reduction at three spatial scales (500m, 1km, and 2km). Models fit using a sample bias grid and the alternative approaches of spatial filtering showed very similar spatial predictions and model performance. The 2km spatial filter reduced the density of records in the high density, heavily sampled eastern margins of the study while maintaining sufficient records in lower density less sampled western areas (Figure 25). The 2km spatial filter appeared to provide the best (reduced bias) spatial representation of the koala records and was adopted as the reference grid scale for use in the final Maxent models. Other koala studies have similarly used a filter to ensure koala records were separated by a minimum distance of 2km to reduce spatial aggregation (Law et al. 2017).

¹⁴ The marginal response curves (partial plots) show how the logistic prediction changes as each environmental variable is varied, while keeping all other environmental variables at their average sample value. The marginal response plots represent the marginal effect of changing only one variable whereas the model may take advantage of sets of variables changing together. The variable response curves were created using only a single variable. The variable response plots reflect the dependence of predicted suitability both on the selected variable and on dependencies induced by correlations between the selected variable and other variables. Consequently, variable response plots may be easier to interpret if there are strong correlations between variables.

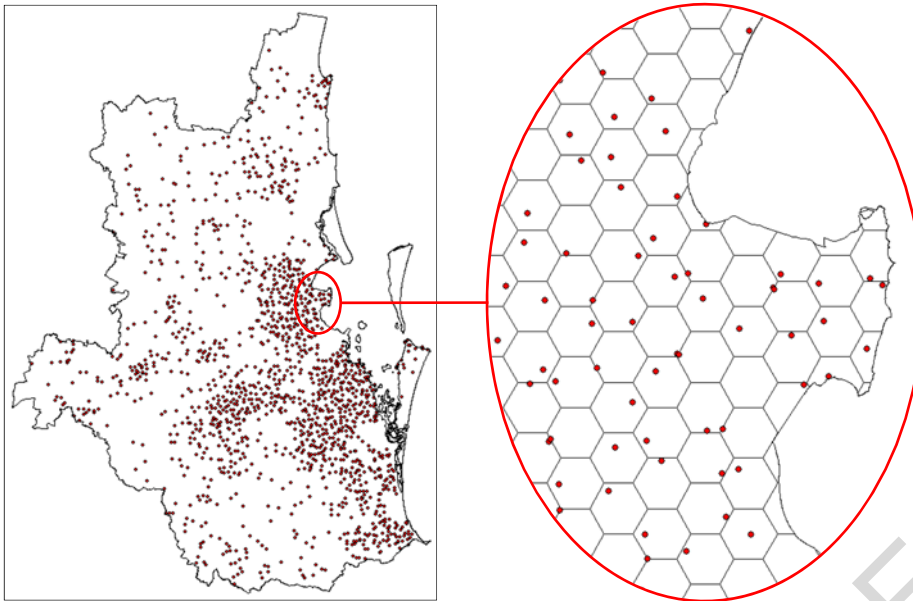


Figure 25: Spatial filtering of koala records (left) using a 2km hexagon (detail) to remove observer bias.

Records spatial filtering trials

Spatial filtering trials were conducted at three spatial scales: 500m, 1km and 2km, equivalent to a hexagon grid cell area of 25ha, 100ha, and 400ha, respectively. Filtering reduced the number of koala occurrence records from a total of 79,936 vetted records in SEQ to 5,417 records in the 25ha grid, 2667 records in the 100ha grid and 1395 records in the 400ha hexagon grid. Further restricting the koala records to mapped areas of remnant or non-remnant (regrowth) vegetation produced smaller subsets used as inputs into the trial Maxent models. By default, Maxent removes duplicate records that occur in a single cell, consequently the final Maxent models were run using a 1ha grid cell, with 1364 presence records used for training and 10,000 random background points used to determine the Maxent distribution (Figure 26).

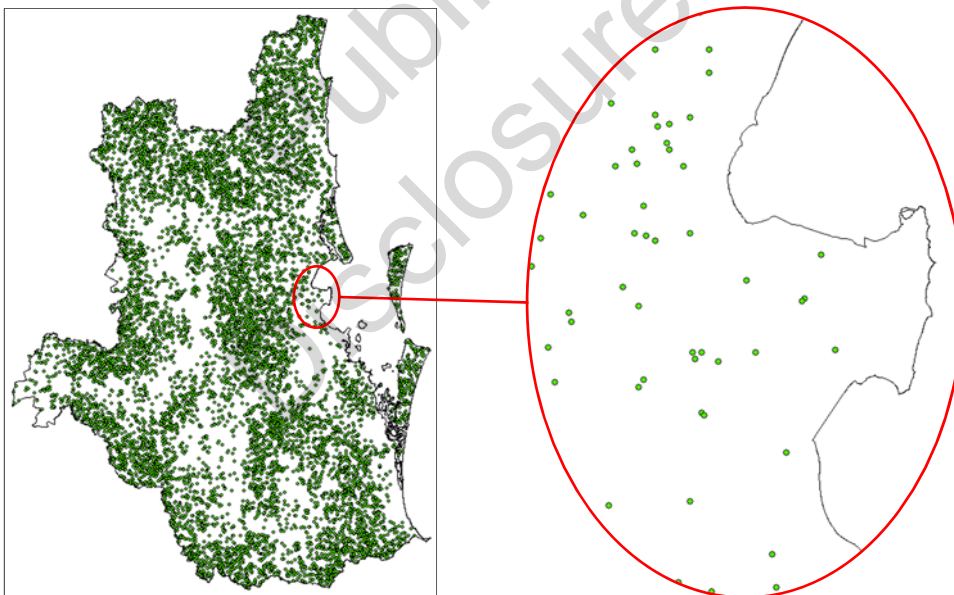


Figure 26: Random background points (left) used to determine the Maxent distribution. Detail (right).

Spatial filtering reduced the spatial aggregation of records but does not correct the lack of data due to low sampling effort in some areas. This method could also underestimate the contribution of suitable areas where the high density of records reflects the true ecological value for the species (Fourcade et al. 2014). In SEQ where large

numbers of koalas occur in urban areas, intermediate road density has been associated with higher koala density (Rhodes et al. 2015) or a reflection of sampling bias towards roads (Briscoe et al. 2016).

Approach

To perform the Maxent run, a csv file containing koala occurrence records (“samples”), a directory containing environmental variables in ASCII format, an output directory for the results and a projection layers directory containing environmental variables in ASCII format were used. All environmental and climate variables were identified within Maxent as continuous variables, except for the GDE variable, which was categorical. The model was trained on a remnant and regrowth mask and predicted to a pre-clearing extent. We used linear, product, quadratic and hinge features (beta hinge = 1.0) to allow for more ecologically relevant response curves that reduced overfitting and that was more suitable for predicting into new environments or future climate scenarios (Elith et al. 2010). Repeated sub-sampling was undertaken using a random test percentage of 20% and 20 replicates to repeatedly split the presence points into random training (80%) and testing (20%) subsets.

Response curves

The marginal response curves (partial plots) (Figure 27) showed a very similar response to the variable response curves using only the corresponding variable (Figure 28). Usually the variable response curves are easier to interpret if there are strong correlations between variables. The shape of the response curves should be considered in the context of an ecological understanding of koala habitat suitability. Variables with complex surfaces may indicate over-fitting and sharp increases or decreases near the limits of the environmental range indicate increased uncertainty.

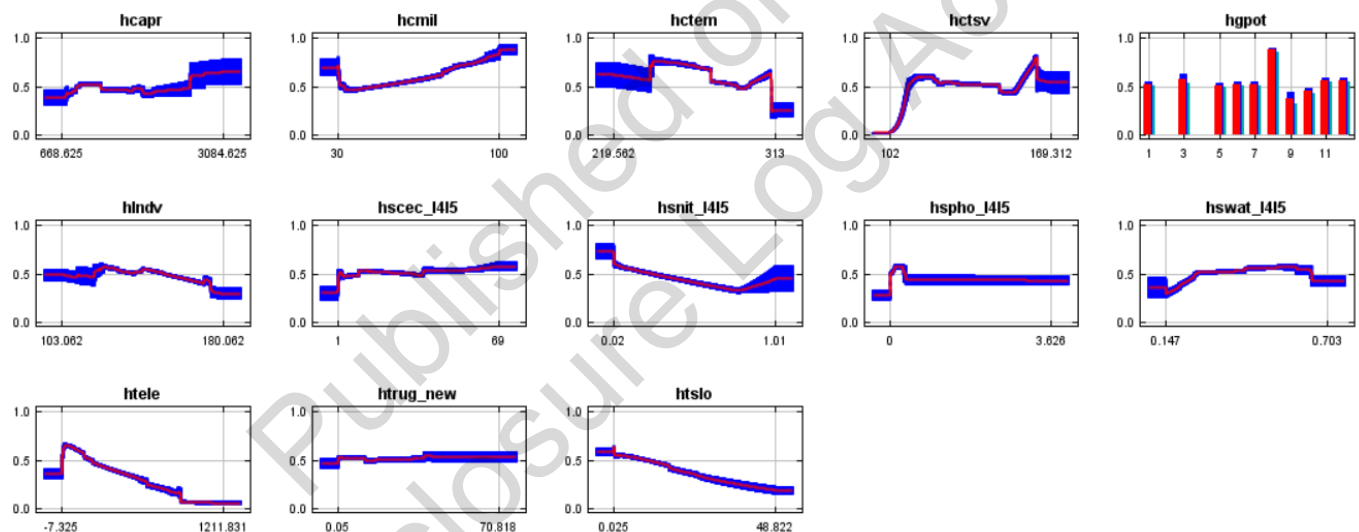


Figure 27: Marginal response curves (partial plots).

Marginal response curves show how predictions change across the range of each environmental variable, keeping all other environmental variables at their average value. (The y-axis represents the logistic value, and the x-axis represents the value of the environmental variable).

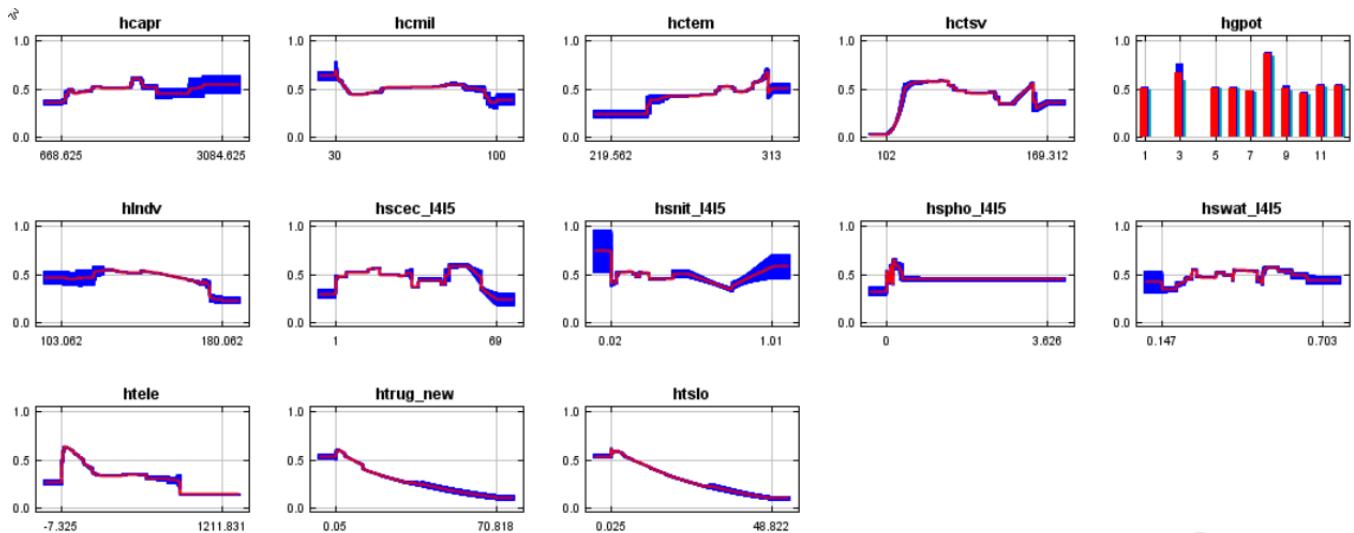


Figure 28: Variable response curves created using only the corresponding variable.

Variable response curves reflect the dependence of predicted suitability both on the selected variable and on dependencies induced by correlations between the selected variable and other variables. They may be easier to interpret if there are strong correlations between variables. (The y-axis represents the logistic value, and the x-axis represents the value of the environmental variable).

Variable contribution

Elevation (htele) was the largest single predictor of koala habitat suitability, contributing 40% to the model. Other measures that contributed more than 4% to the model were temperature coefficient of variation (hctsv), slope (htslo), soil water (hswat), ruggedness (htrug), phosphorous (hspho), temperature (hctem) and potential groundwater dependent ecosystems (GDE) (hgpot) which had a large standard deviation. The top eight measures contributed 88% to the model and consistently ranked higher than the remaining five measures in all model runs. The remaining five measures: moisture index (hcmil), NDVI (hndv), rainfall (hcpr), nitrogen (hsnit) and cation exchange capacity (hscec), each contributed between 2% and 4% to the final model. The low contribution of NDVI and soil fertility measures (such as nitrogen and cation exchange capacity) may be confounded by the better quality soils having been selectively cleared for agriculture (Law et al. 2017).

Maxent settings

Settings used for the final model run and sub-sampling are shown in Table 13.

Table 13: Maxent settings for final run and sub-sampling.

Parameters Main:	Final run	Sub-sampling
Samples directory	--	--
Environmental layers directory	--	--
Linear, quadratic, product, threshold, hinge, auto features	Auto features	Auto features
Create response curves	Yes*	Yes*
Make pictures of predictions	Yes	Yes
Do jackknife to measure variable importance	Yes*	Yes*
Output format (logistic, cumulative, raw)	Logistic	Logistic
Output file type (asc, mxe, grd, bil)	asc	asc
Output directory	--	--
Projection layers directory/file	--	--
Parameters Basic:		
Random seed	Yes*	Yes*

Give visual warnings	Yes	Yes
Show tooltips	Yes	Yes
Ask before overwriting	Yes	Yes
Skip if output exists	No	No
Remove duplicate presence records	Yes	Yes
Write clamp grid when projecting	Yes	Yes
Do MESS analysis when projecting	Yes	Yes
Random test percentage	0	20
Regularization multiplier	1	1
Max number of background points (Default = 10,000)	10,000	10,000
Replicates	1	20
Replicate run type (Crossvalidate, bootstrap, subsample)	(Crossvalidate)	Subsample
Test sample file	n/a	n/a
Parameters Advanced:		
Add samples to background	No*	No*
Add all samples to background	No	No
Write plot data	No	No
Extrapolate	Yes	Yes
Do clamping	Yes	Yes
Write output grids	Yes	No
Write plots	Yes	Yes
Append summary results to maxentResults.csv	No	No
Cache ascii files	Yes	Yes
Maximum iterations (default = 500)	1000*	5000*
Convergence threshold	0.00001	0.00001
Adjust sample radius	0	0
Log file	Maxent.log	Maxent.log
Default prevalence	0.5	0.5
Apply threshold rule (Fixed cumulative value 1, 5, or 10; Minimum training presence; 10 percentile training presence; Equal training sensitivity and specificity; Maximum training sensitivity plus specificity; Equal test sensitivity and specificity; Maximum test sensitivity plus specificity; Equate entropy of thresholded and original distributions)	-	-
Bias file	-	-
Parameters Experimental:		
Logscale raw/cumulative pictures	Yes	Yes
Per species results	No	No
Write background predictions	Yes*	Yes*
Show exponent in response curves	No	No
Fade by clamping	No	No
Verbose	No	No
Use samples with some missing data	No	No
Threads	1	1
Lq to lqp threshold	80	80
Linear to lq threshold	10	10
Hinge threshold	15	15
Beta threshold	-1	-1
Beta categorical	-1	-1
Beta lqp	-1	-1
Beta hinge	-1	-1
Default nodata value	-9999	-9999

*Non-default settings with the asterisk were changed and all other settings remained as default.

Maxent model validation

The results here are for the initial Maxent model (version 11.17) because the model was not re-run but was projected into small new areas reflecting the boundary change to the SEQ regional planning area.

Area under the curve (AUC) as a measure of model performance

The cross-validation AUC derived from the ROC shows only a small amount of variability between models (Figure 29), indicating that the model was a good fit. The mean AUC on the test data was 0.706 (95% CI: 0.700–0.712; SD $\pm$ 0.0013; range 0.673–0.730, n = 20). The mean AUC on the training data was 0.740 (95% CI: 0.738–0.741; SD $\pm$ 0.004; range 0.731–0.746, n = 20).

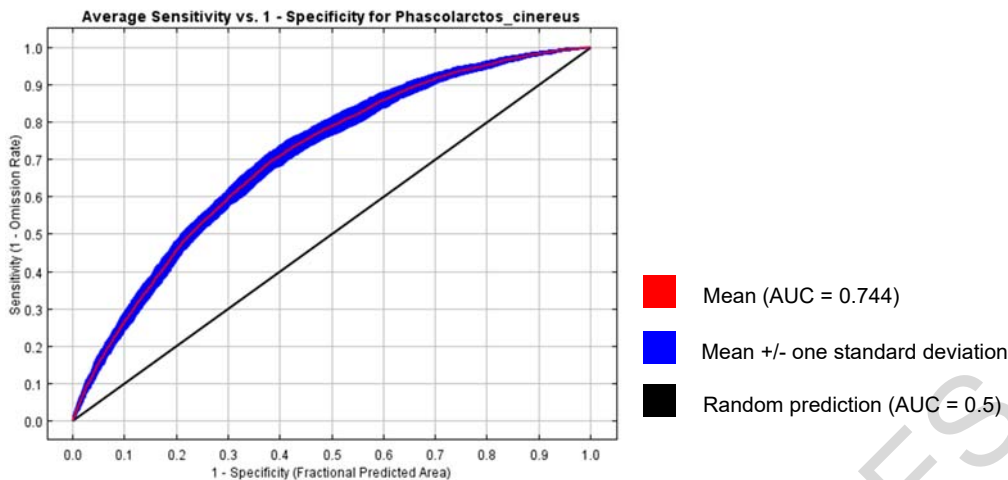


Figure 29: Cross validation AUC indicating the model was a good fit with only small amounts of variability (blue).

Mean habitat suitability and standard deviation

Mean habitat suitability logistic values from the repeated sub-sampling ranged from 0.009 to 0.962 (mean suitability = 0.450 and standard deviation of suitability = 0.173). The standard deviation of habitat suitability was low, with mean standard deviation = 0.031 (range 0.004–0.250) indicating again that the model was a good fit (Figure 30).

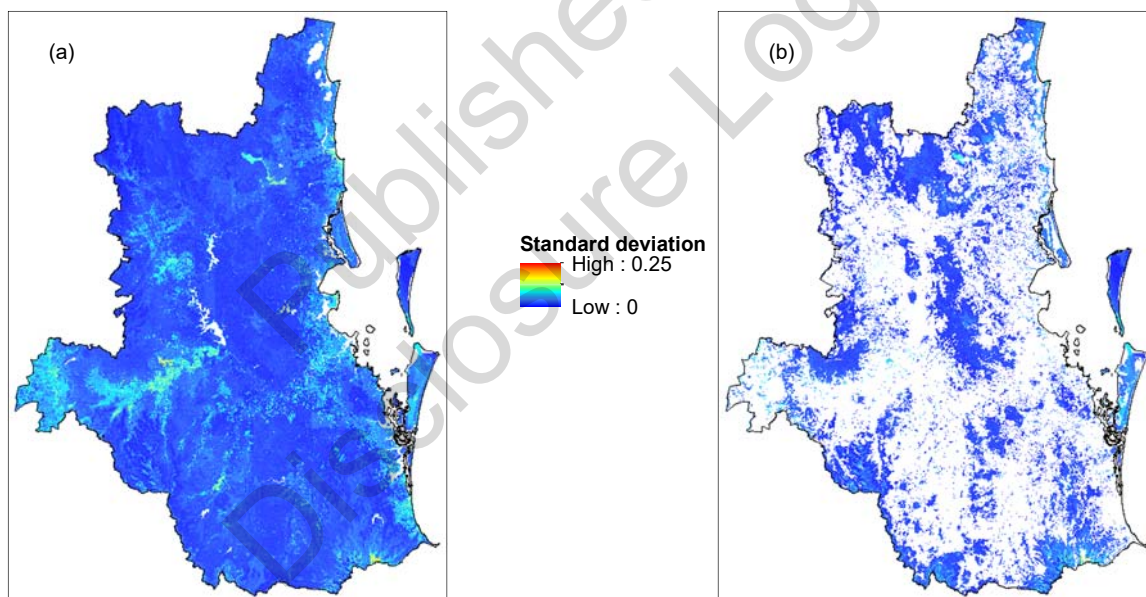


Figure 30: Maxent model standard deviation. Pre-clearing (a) and remnant (b).

Analysis of the variability associated with the predictor variables in the cross-validation

In the cross-validation, two measures elevation (htele) and potential GDE (hgpot) contributed 52% to the model, followed by seasonality coefficient of variation (hctsv) and slope (htslo) which contributed 21%. All other variables contributed less than 5% to the model (Table 14).

Table 14: Contribution of each variable (measure) to the Maxent model.

Measure	Measure code	Mean	Standard deviation	Min	Max	Range
Elevation	htele	26.2	6.3	19.7	38.5	18.9
GDE	hgpot	25.4	9.2	4.8	36.3	31.5
Seasonality	hctsv	12.2	1.7	9.9	15.5	5.6
Slope	htslo	8.9	2.1	4.8	12.2	7.4
Ruggedness	htrug	4.8	1.5	2.4	8.0	5.7
Temperature	hctem	4.2	0.5	3.4	5.5	2.1
Soil water	hswat	3.8	1.4	2.0	6.5	4.4
Phosphorus	hspho	3.0	1.0	1.6	5.5	3.9
Moisture index	hcmil	3.0	0.6	2.1	4.8	2.7
Cation exchange capacity	hscec	2.5	0.4	1.8	3.2	1.4
Nitrogen	hsnit	2.4	0.4	1.7	2.9	1.2
NDVI	hlndv	2.3	0.5	1.6	3.4	1.8
Rainfall	hcapr	1.3	0.4	0.6	2.0	1.4

The contribution of GDE (hgpot) was highly variable with a high standard deviation (9.2%) and large range (31.4%), with a contribution as low as 4.8% and as high as 36.3%. Consequently a single model run could yield a low contribution for GDE, purely by chance (Figure 31).

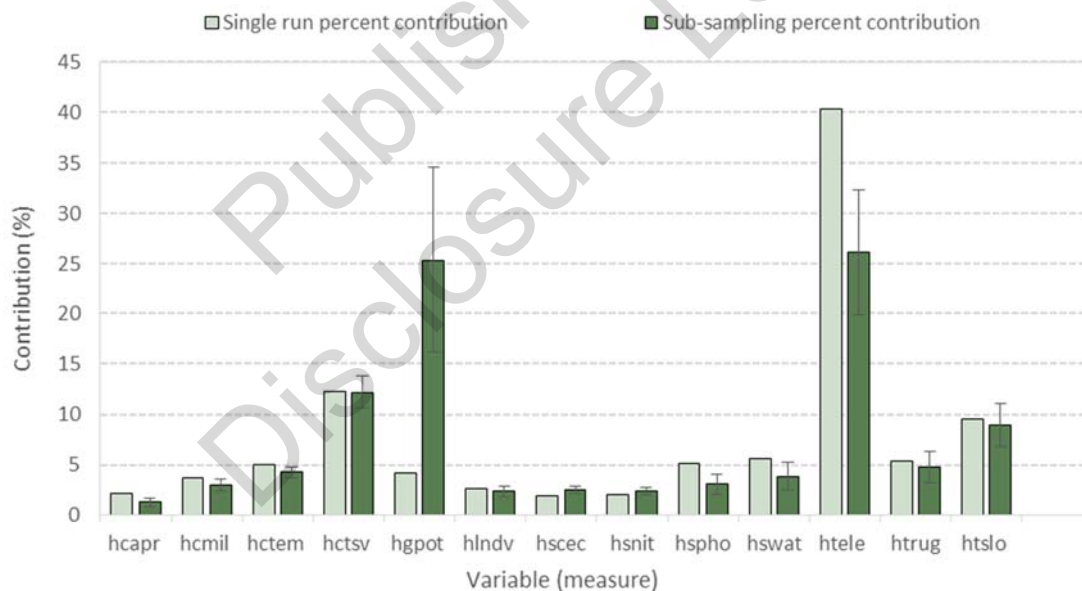


Figure 31: Variable importance from the single run used in the model compared with sub-sampling.

Analysis of the response curves of the predictor variables

The variable response curves, using only the corresponding variable, showed a very similar response to the marginal response curves (partial plots) indicating that correlations between variables has not been a major factor in fitting the model (Figure 32). The response curves for elevation (htele) and slope (htslo) (Figure 32) showed a

strong inverse relationship indicating the highest suitability koala habitat predicted at elevations below 220m (mean = 107m +/- 115m SD), moderate suitability from 200 – 900m with the lowest suitability at elevations above 900m altitude. The highest ranked koala habitat suitability was predicted to occur on gentle slopes (low inclines).

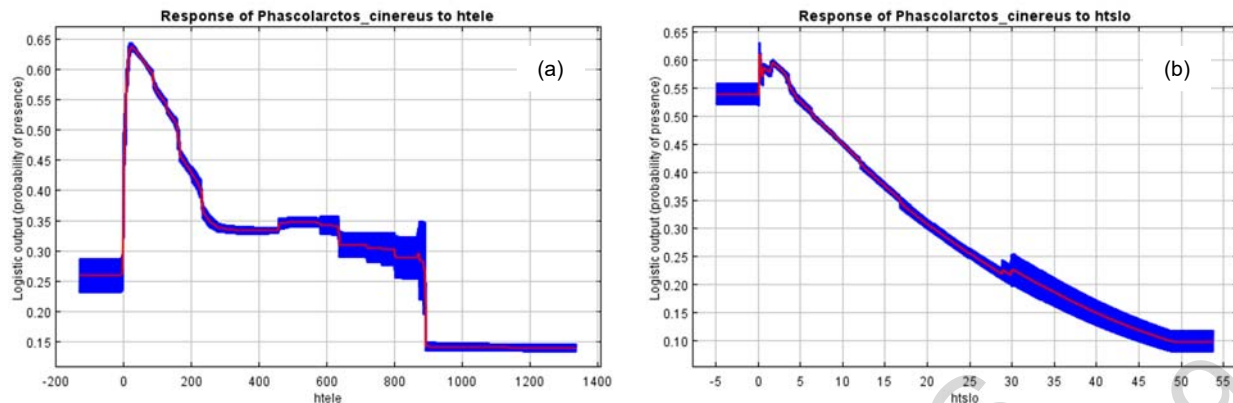


Figure 32: Examples of variable response curves. (a) Elevation (htele) and (b) slope (htslo).

The variable response curves show a strong inverse relationship between koala habitat suitability and both elevation and slope, indicating that the highest ranked koala habitat was predicted at low elevations (below 222m) and low slopes (inclines).

Maxent input data layers and training mask

Table 15: Maxent input data layers description and rationale.

Criteria	Indicator	Measure name, code and units	Source data	Summary description and data range	Rationale for inclusion
Habitat	Terrain	Elevation (htele) Mean altitude (m)	Digital Elevation Model (DEM) based on a 1 sec grid cell SIR: SRTM2_DSM_DEMv1_0 1 second (~30m) raster	Derived from the National DEM Shuttle Radar Topographic Mission (SRTM) 1 Second. The DEM represents ground surface topography, with vegetation features removed using an automatic process supported by several vegetation maps. Elevations are expressed as metres above sea level (MASL). For the Maxent 100m raster, range: -6.1–1225.3 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	In inland areas to the west, koalas are associated with the eucalypt communities associated with rivers and watercourses. To the east, koalas are regarded as being most abundant in the forests of the foothills and coastal plains (Martin et al. 2008). Low altitude areas are associated with some depositional flood plains and coastal lowlands that have higher fertility soils linked to higher koala densities (Rhodes et al. 2008, Crowther et al. 2009). Elevation is also linked to temperature and rainfall.
Habitat	Terrain	Slope (htslo) Mean slope (degrees)	DEM based on a 1 sec grid cell SIR: SRTM2_DSM_DEMv1_0 1 second (~30m) raster	Slope is a measure of steepness and is derived from the DEM and expressed as the average degrees over a 30m grid cell. For the Maxent 100m raster, range: 0–55.1 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Slope has an important indirect influence on koala occurrence and density because steeply sloping areas tend to have lower soil fertility and lower soil moisture and represent poorer koala habitat (Crowther et al. 2009) incidental koala records in SEQ (n=35,930) occur on low slopes between zero and five degrees (H. Preece 2015 pers. comm.).
Habitat	Terrain	Ruggedness (htrug) Terrain ruggedness (index)	Terrain ruggedness index derived from DEM based on a 1 sec grid cell SIR: SRTM2_DSM_DEMv1_0 1 second (~30m) raster	Topographic ruggedness is an index used to quantify topographic heterogeneity. It expresses the amount of elevation difference between adjacent cells of a DEM. The ruggedness index value is calculated for every location, by summarizing the change in elevation within a 3x3 pixel grid. The ruggedness index values were not grouped into categories, used as continuous data. For the Maxent 100m raster, range: 0–85.4 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Koala habitat is often associated with vegetation communities that occur on higher fertility and higher moisture soils at lower elevations and on lower slopes such as blue gum (<i>E. tereticornis</i>) communities on alluvial plains (Melzer et al. 2000).

Criteria	Indicator	Measure name, code and units	Source data	Summary description and data range	Rationale for inclusion
Habitat	Soil	Cation exchange capacity (CEC) (hscec) Concentrations of cations expressed in centimoles of positive charge per kilogram of soil (cmol (+)/kg)	Australian Soil Resource Information System (ASRIS). Vector representation of 250m raster. Soil_L4/L5 SIR: SLR.QLD_SOILS_ASRIS Feature Class: SLR.ASRIS_ASR_L4_2M_RESULTS_V and LR.QLD_SOILS_ASRIS\SLR.ASRIS_ASR_L5_250K_RESULTS_V	Cations are positively charged ions such as calcium (Ca ²⁺), magnesium (Mg ²⁺), potassium (K ⁺), sodium (Na ⁺) hydrogen (H ⁺), aluminium (Al ³⁺), iron (Fe ²⁺), manganese (Mn ²⁺), zinc (Zn ²⁺) and copper (Cu ²⁺). The capacity of the soil to hold on to these cations is the cation exchange capacity (CEC). Adding the concentrations of each cation gives an estimate of the CEC figure. A figure above 10cmol (+)/kg is preferred for plant production. Soils with high levels of swelling clay and organic matter can have a CEC of 30cmol (+)/kg or more. The five exchangeable cations are also shown in soil test results as percentages of CEC. The desirable ranges for them are: calcium 65–80% of CEC, magnesium 10–15%, potassium 1–5%, sodium 0–1% and aluminium 0%. The soil_L4/L5 layer was dissolved on the CEC_3 field. (NULL, -1234 and -9999 values are not included) For the Maxent 100m raster, range: 1–69 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Koalas prefer high fertility soils because they influence the foliar nutrients and moisture available to koalas through the leaves they consume (Moore and Foley 2005). Cation exchange capacity (CEC) is a useful indicator of soil fertility because it shows the soil's ability to supply three important plant nutrients: calcium, magnesium and potassium.
Habitat	Soil	Phosphorus (hspho) Mean mass fraction of total phosphorus in the soil by weight (%)	Australian Soil Resource Information System (ASRIS). Vector representation of 250m raster. Soil_L4/L5 SIR: SLR.QLD_SOILS_ASRIS Feature Class: SLR.ASRIS_ASR_L4_2M_RESULTS_V and LR.QLD_SOILS_ASRIS\SLR.ASRIS_ASR_L5_250K_RESULTS_V	Mass fraction of total phosphorus in the soil by weight in layer 1 (soil depth 0–5 cm). For the Maxent 100m raster, range: 0–1.663 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Koalas are believed to prefer browse with higher phosphorus and potassium (Ullrey et al. 1981). Phosphorous is critical for the overall health of eucalypts, including the development of roots, stems, flowers and seeds and is vital for photosynthesis in plants and for growth in animals. Phosphorous is a critical limiting nutrient in most Australian soils which are naturally low in phosphorus due to extensive and prolonged weathering. While native plants are adapted to these low levels, introduced grasses are not, which is why Australian farmers use much more phosphorus than farmers in Europe and USA. Chemically, phosphorus is a very stable element, binding with iron and aluminium in the soil and becoming unavailable to plants - especially in dry soils.

Criteria	Indicator	Measure name, code and units	Source data	Summary description and data range	Rationale for inclusion
Habitat	Soil	Nitrogen (hsnit) Mean mass fraction of total nitrogen in the soil by weight (%)	Australian Soil Resource Information System (ASRIS). Vector representation of 250m raster. Soil_L4/L5 SIR: SLR.QLD_SOILS_ASRIS Feature Class: SLR.ASRIS_ASR_L4_2M_RESULTS_V and LR.QLD_SOILS_ASRIS\SLR.ASRIS_ASR_L5_250K_RESULTS_V	Total nitrogen content of soils is the mass fraction of total nitrogen in the soil by weight and is a key soil attribute influencing the nutrient content of eucalypt trees (Cork 1986). The soil_L4/L5 layer was dissolved on the TOTAL_N_1 field. (NULL, -1234 and -9999 values were not included) For the Maxent 100m raster, range: 0.02–1.22 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Nitrogen is believed to be a major limiting factor influencing the abundance of koalas (Degabriele 1981). Koalas are believed to preferentially visit trees with leaves containing higher available nitrogen, used by the body to make proteins, and avoid trees with higher levels of toxic chemicals (Cork 1986). In habitats of low nutritional quality, a diversity of tree species is believed to be particularly important, in order to provide koalas with a choice of browse ranging in nutritional quality and minimizing the need to move to forests with higher quality leaves (Stalenberg et al. 2014).
Habitat	Soil	Soil water (hswat) Mean plant available water (mm)	Australian Soil Resource Information System (ASRIS). Vector representation of 250m raster. Soil_L4/L5 SIR: SLR.QLD_SOILS_ASRIS Feature Class: SLR.ASRIS_ASR_L4_2M_RESULTS_V and LR.QLD_SOILS_ASRIS\SLR.ASRIS_ASR_L5_250K_RESULTS_V	Plant available water is the amount of water in the soil which can be extracted by a plant. It is the difference between field capacity (the maximum amount of water the soil can hold) and the wilting point (where the plant can no longer extract water from the soil). Plant available water was calculated by subtracting the wilting point from the field capacity. The soil water measure was calculated by subtracting the sum of the wp1-5 fields from the sum of the fc1-5 fields, (NULL, -1234 and -9999 values were not included) For the Maxent 100m raster, range: 0.046–0.782 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Koalas are dependent on leaf moisture content for all their water needs where they do not have access to free-standing water or moisture on leaves (Gordon et al 1988, Ellis et al 2010). In dry seasons, drought and hot conditions, water may be a limiting factor that results in koala death. The health of the tree canopy, foliar moisture and nutrients are dependent on available soil moisture (Moore et al. 2004).
Habitat	Climate	Temperature (hctem) Maximum temperature of warmest period (°C x 10)	Bioclim (BioClimatic 3 seconds data): bc5_mtwp/Bio5 http://fennerschool.anu.edu.au/files/anuclim61.pdf Bioclimatic parameters for Queensland (90m raster) derived using ANUCLIM/BIOCLIM version 5.1 (Houlder et al. 2000) and a 90m SRTM DEM. Data obtained from the Queensland Herbarium, (DSITI 2016).	Maximum temperature of warmest period (°C x 10). Value (in °C) multiplied by 10 in source data. Calculated as the highest temperature of any weekly maximum temperature. For the Maxent 100m raster, range: 216.25–313 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Temperature information is useful when examining whether species distributions are affected by warm temperature anomalies throughout the year (O'Donnell and Ignizio 2012). High maximum summer temperatures have been found to be important determinants of koala mortalities (Gordon et al. 1988) and distributions (Lunney et al. 2012, Lunney et al. 2014, Santika et al. 2014). Koala populations are believed to be currently confined to areas with a maximum summer temperature below 37.7°C (i.e. maximum temperature of warmest period) and maximum annual rainfall below 2480mm (i.e. mean annual precipitation) (Adams-Hosking et al. 2011).

Criteria	Indicator	Measure name, code and units	Source data	Summary description and data range	Rationale for inclusion
Habitat	Climate	Rainfall (hcapr) Annual average mean precipitation per year (mm/year)	Bioclim (BioClimatic 3 seconds data): bc12_ap/Bio ₁₂ http://fennerschool.anu.edu.au/files/anuclim61.pdf Bioclimatic parameters for Queensland (90m raster) derived using ANUCLIM/BIOCLIM version 5.1 (Houlder et al. 2000) and a 90m SRTM DEM. Data obtained from the Queensland Herbarium (DSITI 2016).	Annual mean precipitation per year (mm/year). Calculated as the sum of all monthly precipitation estimates For the Maxent 100m raster, range: 666.0625–2751.625 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Annual total precipitation approximates the total water inputs and is therefore useful when ascertaining the importance of water availability to a species distribution (O'Donnell and Ignizio 2012). Rainfall is important for koalas as they are sensitive to drought (Seabrook et al. 2011). Drought reduces the leaf moisture content and the nutrition of eucalypt leaves that are important for koala habitat quality (Moore et al. 2004). Koala populations are currently confined to areas with maximum annual rainfall of 2480mm (mean annual precipitation of 863mm; minimum 234mm) (Adams-Hosking et al. 2011).
Habitat	Climate	Moisture index (hcmil) Mean moisture index of the lowest quarter moisture (index)	Bioclim (BioClimatic 3 seconds data): bc33_mmilq/Bio ₃₃ http://fennerschool.anu.edu.au/files/anuclim61.pdf Bioclimatic parameters for Queensland (90m raster) derived using ANUCLIM/BIOCLIM version 5.1 (Houlder et al. 2000) and a 90m SRTM DEM. Data obtained from the Queensland Herbarium, (DSITI 2016).	The quarter of the year having the lowest average moisture index value is determined (to the nearest week), and the average moisture index value is calculated (Xu and Hutchinson, 2011, 2013) For the Maxent 100m raster, range: 29.0625–100 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Koalas are dependent on leaf moisture content for all their water needs where they do not have access to free-standing water or moisture on leaves (Gordon et al. 1988, Ellis et al. 2010). In dry seasons, drought and hot conditions, water may be a limiting factor that results in koala death (Gordon et al. 1988).

Criteria	Indicator	Measure name, code and units	Source data	Summary description and data range	Rationale for inclusion
Habitat	Climate	Seasonality (hcstv) Temperature seasonality coefficient of variation (Kelvin)	Bioclim (BioClimatic 3 seconds data): bc4_ts/Bio4 http://fennerschool.anu.edu.au/files/anuclim61.pdf Bioclimatic parameters for Queensland (90m raster) derived using ANUCLIM/BIOCLIM version 5.1 (Houlder et al. 2000) and a 90m SRTM DEM. Data obtained from the Queensland Herbarium (DSITI 2016).	The temperature coefficient of variation is the standard deviation of the weekly mean temperatures expressed as a percentage of the mean of those temperatures (i.e. the annual mean). For this calculation, the mean in Kelvin (K) is used. This avoids the possibility of having to divide by zero, but does mean that the values are usually quite small (Xu and Hutchinson, 2011, 2013) For the Maxent 100m raster, range: 103–170 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	Temperature seasonality is a measure of temperature change over the course of the year. Temperature seasonality coefficient of variation captures the dispersion in relative terms because standard deviation can produce two similar values while the means may be different. However, if variance is the same, an area with a lower mean temperature is distinguishable from an area with similar variance but with a higher mean temperature. The larger the percentage, the greater the variability of temperature (O'Donnell and Ignizio 2012) Reported by Queensland Herbarium (2012) in a study of Queensland threatened flora and fauna as an important driver of species distribution.
Habitat	Land cover	Normalised difference vegetation index (NDVI) (hndv) (index)	NDVI Sentinel-2 data Department of Science, Information Technology and Innovation (2016)	NDVI provides a measure of the amount of live green vegetation. NDVI is the ratio of reflectance in two spectral bands located in the red and near infrared wavelengths. This index can be used to provide an indication of greenness and net primary productivity based on the fraction of absorbed photosynthetically active radiation. NDVI was calculated using 554 Sentinel-2 NDVI images captured between 29/9/2015 and 16/11/2016 and computing the 25th percentile of NDVI after cloud masking. Calculating percentiles over time establishes the typical vegetation conditions for that period. Units are NDVI*100+100. So 100 is 0.0, 200 is 1.0 etc. (P. Scarth 2016 pers. comm.). NDVI values of zero mean there is no green vegetation, intermediate values represent sparse vegetation, shrubs or grassland and values of +1.0 represent dense green vegetation. NDVI values are always between -1 and +1, with the lowest value (-1) representing deep water. Vegetation NDVI in Australia typically ranges from 0.1 to 0.7, with higher values associated with greater density and greenness of the plant canopy. NDVI decreases as leaves come under water stress, become diseased or die. Bare soil and snow values are close to zero, while water bodies have negative values. For the Maxent 100m raster, range: 100–178.3125 Datatype source/Maxent: Continuous/Continuous Derived for study: Raster	NDVI has been used in various species models to represent potential habitat. Koalas are obligate folivores feeding on the foliage of eucalypts and closely related tree species to obtain all their food and the majority of their water. NDVI can be used to provide an indication of potential food and habitat availability as well as leaf moisture availability and habitat quality (Santika et al. 2014, Youngentob et al. 2015, Law et al. 2017).

Criteria	Indicator	Measure name, code and units	Source data	Summary description and data range	Rationale for inclusion																																							
Habitat	Ground water	Potential Groundwater Dependant Ecosystem (GDE) (hgpot) (category)	Department of Environment and Heritage Protection (2016)	<p>GDEs are ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (DSITI 2015). Ecosystem dependency on groundwater may vary temporally (over time) and spatially (depending on its location in the landscape).</p> <p>Range: Groundwater connectivity and salinity were combined into twelve classes using a two digit code where the first digit represents connectivity and the second digit represents salinity. Connectivity values (GW_CON_T_D): 1 = Permanent, 2 = Near-permanent, 3 = Intermittent. Salinity values (GW_SALINTY): 1 = Freshwater (salinity < 1500 mg/L TDS), 2 = Brackish (salinity 1500 - 3000 mg/L TDS), 3 = Fluctuating salinity, 4 = Saline (salinity 3000 - 35000 mg/L TDS). C_MODEL = Recharge or Exclusion zones.</p> <table><thead><tr><th>Class</th><th>Code</th><th>Rule</th></tr></thead><tbody><tr><td>1</td><td>11</td><td>Permanent and freshwater</td></tr><tr><td>2</td><td>12</td><td>Permanent and brackish</td></tr><tr><td>3</td><td>13</td><td>Permanent and fluctuating salinity</td></tr><tr><td>4</td><td>14</td><td>Permanent and saline</td></tr><tr><td>5</td><td>21</td><td>Near-permanent and freshwater</td></tr><tr><td>6</td><td>24</td><td>Near-permanent and saline</td></tr><tr><td>7</td><td>31</td><td>Intermittent and freshwater</td></tr><tr><td>8</td><td>32</td><td>Intermittent and brackish</td></tr><tr><td>9</td><td>33</td><td>Intermittent and fluctuating salinity</td></tr><tr><td>10</td><td>34</td><td>Intermittent and saline</td></tr><tr><td>11</td><td>51</td><td>Recharge zones</td></tr><tr><td>12</td><td>52</td><td>Exclusion zones</td></tr></tbody></table> <p>Datatype source/Maxent: Categorical/Categorical</p> <p>Derived for study: Raster</p>	Class	Code	Rule	1	11	Permanent and freshwater	2	12	Permanent and brackish	3	13	Permanent and fluctuating salinity	4	14	Permanent and saline	5	21	Near-permanent and freshwater	6	24	Near-permanent and saline	7	31	Intermittent and freshwater	8	32	Intermittent and brackish	9	33	Intermittent and fluctuating salinity	10	34	Intermittent and saline	11	51	Recharge zones	12	52	Exclusion zones	Vegetation within GDEs is suspected to be more resilient to climate change impacts and contain vegetation (leaves) with higher water availability and better able to supply the moisture koalas obtain from their browse. Koala trees will have better moisture where there is permanent or near permanent connectivity to an aquifer where the groundwater is fresh (T. Ryan 2016 pers. comm.).
Class	Code	Rule																																										
1	11	Permanent and freshwater																																										
2	12	Permanent and brackish																																										
3	13	Permanent and fluctuating salinity																																										
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7	31	Intermittent and freshwater																																										
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10	34	Intermittent and saline																																										
11	51	Recharge zones																																										
12	52	Exclusion zones																																										

Table 16: Vegetation data and Maxent training mask.

Name	Source	Description
Remnant (hvrem) Pre-clearing (hvpre)	Regional ecosystem version 10.0, Queensland Herbarium, (DSITI 2016), published 14 December 2016. Based on 2015 Landsat imagery.	<p>Remnant and pre-clearing regional ecosystem mapping (version 10.0) were used as a training mask in the Maxent model (v11.17). Remnant (hvrem) and regrowth (hvreg) vegetation were combined and used as a training mask (hvrrc) to restrict koala occurrence records to only areas with trees and prevent the model being trained in cleared area without trees.</p> <p>Remnant and pre-clearing vegetation mapping (version 10.0) were sourced from the Queensland Herbarium (December 2016). Map scale range 1:25,000 – 1:100,000. Map scales: 1:25,000 (Brisbane); 1:50,000 (Gold Coast, Moreton Bay, Redland, Sunshine Coast, Gatton, Toowoomba and pre-amalgamation portion of Logan); 1:75,000 (Noosa and Beaudesert portion incorporated into Logan); and 1:100,000 (Laidley, Scenic Rim, Somerset) (Tim Ryan 2016 pers. comm.). Positional accuracy of RE data, mapped at a scale of 1:100,000, is 100m.</p>
Regrowth (hvreg)	Woody cover raster data (offsets regrowth mapping). Biodiversity Implementation & Offsets Team. Department of Environment and Heritage Protection (2015)	<p>Regrowth (EHP 2015) was used as a training mask in the Maxent model (v11.17). Remnant (hvrem) and regrowth (hvreg) vegetation were combined and used as a training mask (hvrrc) to restrict koala occurrence records to only areas with trees and prevent the model being trained in cleared area without trees.</p> <p>The regrowth mapping (from the offsets program) was a vector-format derivative of the state-wide, 30m resolution foliage projection cover (FPC) raster (generated from Landsat imagery). The dataset was initially created by the offsets program (EHP 2015) and spatially filtered (masked) to reduce non target landuses (such as cropping, horticulture, industrial and urban etc) for the koala habitat suitability model v1.2. (See spatial filtering below). The offsets regrowth layer consists of a binary classification of non-remnant areas as either woody or non-woody, on the basis of whether local FPC values are above or below empirically generated woody/non-woody FPC cut-off values held in separate 'cut-off' raster (EHP 2015). The regrowth layer was erased with the remnant RE (version 10) mapping to remove potential overlaps.</p>

Appendix 7. Koala habitat matrix areas

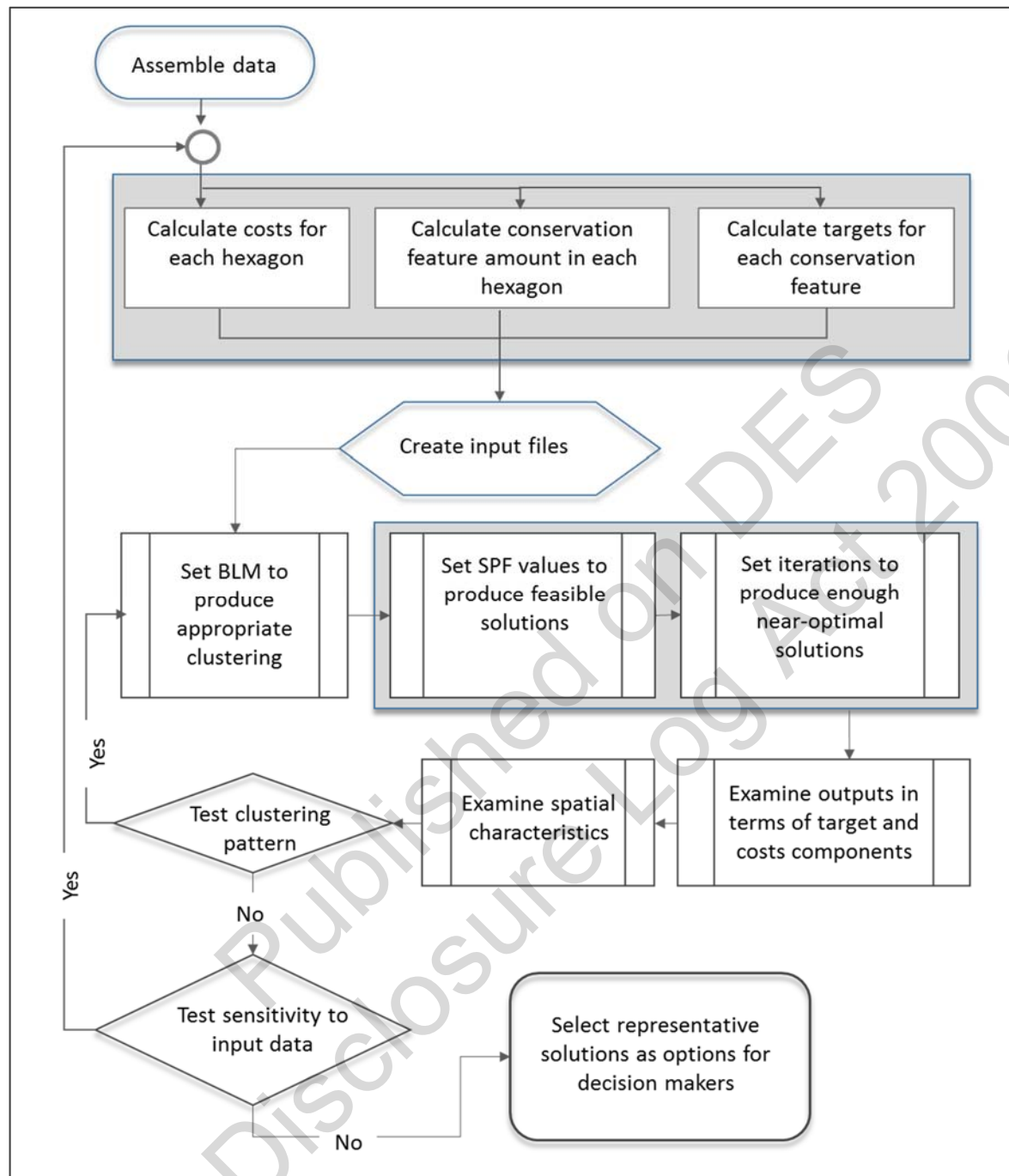
The following tables summarise the area (hectares) of the different koala habitat matrix classes. The tables show the pre-clearing and current (remnant) extent for each class of koala habitat in SEQ. The amount of koala habitat for each matrix rule and suitability category can be found using Figure 6 and Figure 7 as a reference. Note, areas have been calculated using MGA56.

Pre-clearing area (ha)			Regional Ecosystem Suitability (RE rank)					TOTAL
			High 5	Medium 4	Low 3	Very low 2	Non-habitat 1	
Maxent Suitability (Maxent Rank)	High 3	Record 1	376001	889470	45067	67875	13173	1391585
		No Record 0	24438	80736	13593	8201	8663	135632
	Medium 2	Record 1	20854	275665	30602	34089	3675	364884
		No Record 0	5978	67710	21224	14684	10750	120346
	Low 1	Record 1	7294	86350	6144	24360	13551	137700
		No Record 0	1929	52126	9532	32964	12131	108681
TOTAL			436494	1452057	126161	182173	61943	2258828

Remnant area (ha)			Regional Ecosystem Suitability (RE rank)					TOTAL
			High 5	Medium 4	Low 3	Very low 2	Non-habitat 1	
Maxent Suitability (Maxent Rank)	High 3	Record 1	32,423	160,315	22,390	12,772	5,346	233,246
		No Record 0	6,359	38,806	7,764	4,387	2,848	60,162
	Medium 2	Record 1	8,418	159,659	17,977	22,403	2,042	210,500
		No Record 0	2,883	49,757	12,007	13,275	2,361	80,284
	Low 1	Record 1	2,489	54,955	4,349	15,846	13,317	90,957
		No Record 0	1,509	59,171	9,074	29,981	7,620	107,356
		TOTAL	54,081	522,663	73,560	98,665	33,534	782,504

Appendix 8. Marxan workflow

Workflow for running Marxan, modified from (Fischer et al. 2013). BLM is the boundary length modifier, SPF is the species penalty factor



Appendix 9. Koala habitat model for southern SEQ

The habitat model integrated a species distribution model with the Queensland Herbarium's regional ecosystem (RE) mapping and validated koala occurrence records to produce a comprehensive ranking of koala habitat suitability across the SEQ study area (Figure 33). The categories of the habitat model represent core habitat, non-core habitat, and non-habitat. Classes 4–10 represent core habitat, with class 4 the lowest suitability core habitat without confirmed koala sightings and class 10 the highest suitability core habitat. Classes 2–3 represent non-core habitat, with class 2 representing non-core (marginal) habitat, class 3 representing non-core (rainforest) habitat. Class 1 represents non-habitat. The map of habitat categories is shown in Figure 34.

			Regional Ecosystem Suitability (RE Rank)				
			High 5	Medium 4	Low 3	Very low 2	Non-habitat 1
Maxent Suitability (Maxent Rank)	High 3	Record 1	Rule 351 10	Rule 341 9	Rule 331 8	Rule 321 3	Rule 311 1
		No Record 0	Rule 350 10	Rule 340 9	Rule 330 8	Rule 320 3	Rule 310 1
	Medium 2	Record 1	Rule 251 7	Rule 241 6	Rule 231 5	Rule 221 3	Rule 211 1
		No Record 0	Rule 250 4	Rule 240 4	Rule 230 4	Rule 220 3	Rule 210 1
	Low 1	Record 1	Rule 151 2	Rule 141 2	Rule 131 2	Rule 121 3	Rule 111 1
		No Record 0	Rule 150 2	Rule 140 2	Rule 130 2	Rule 120 1	Rule 110 1

Figure 33: Decision matrix and koala habitat suitability categories.

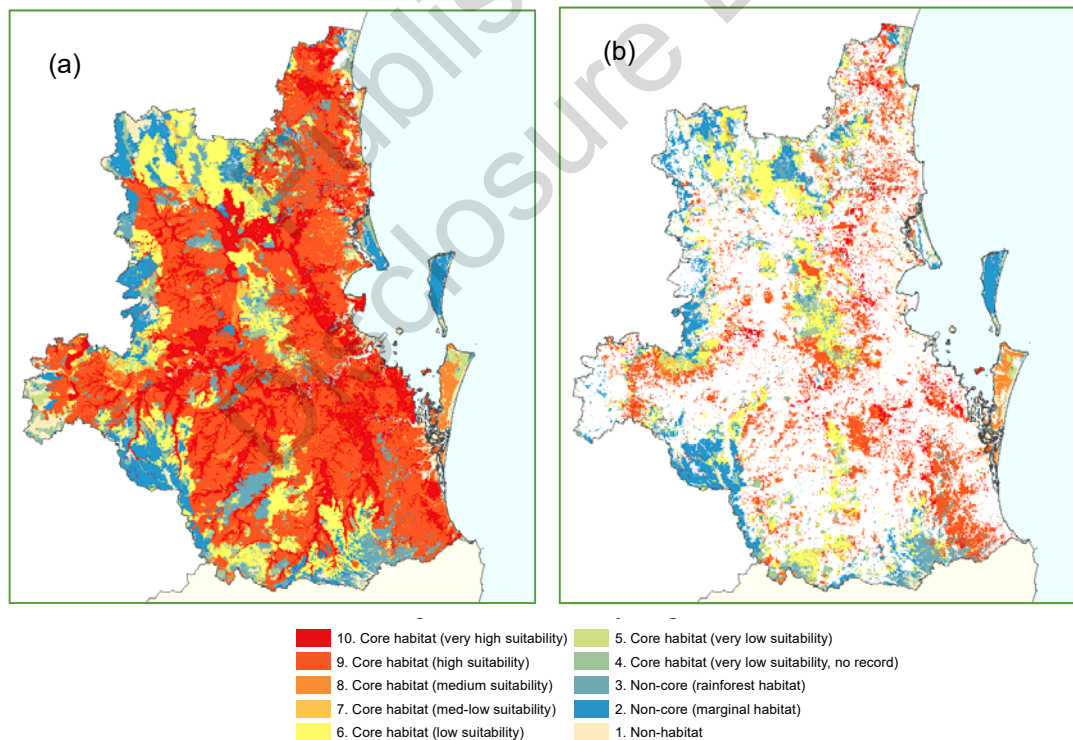
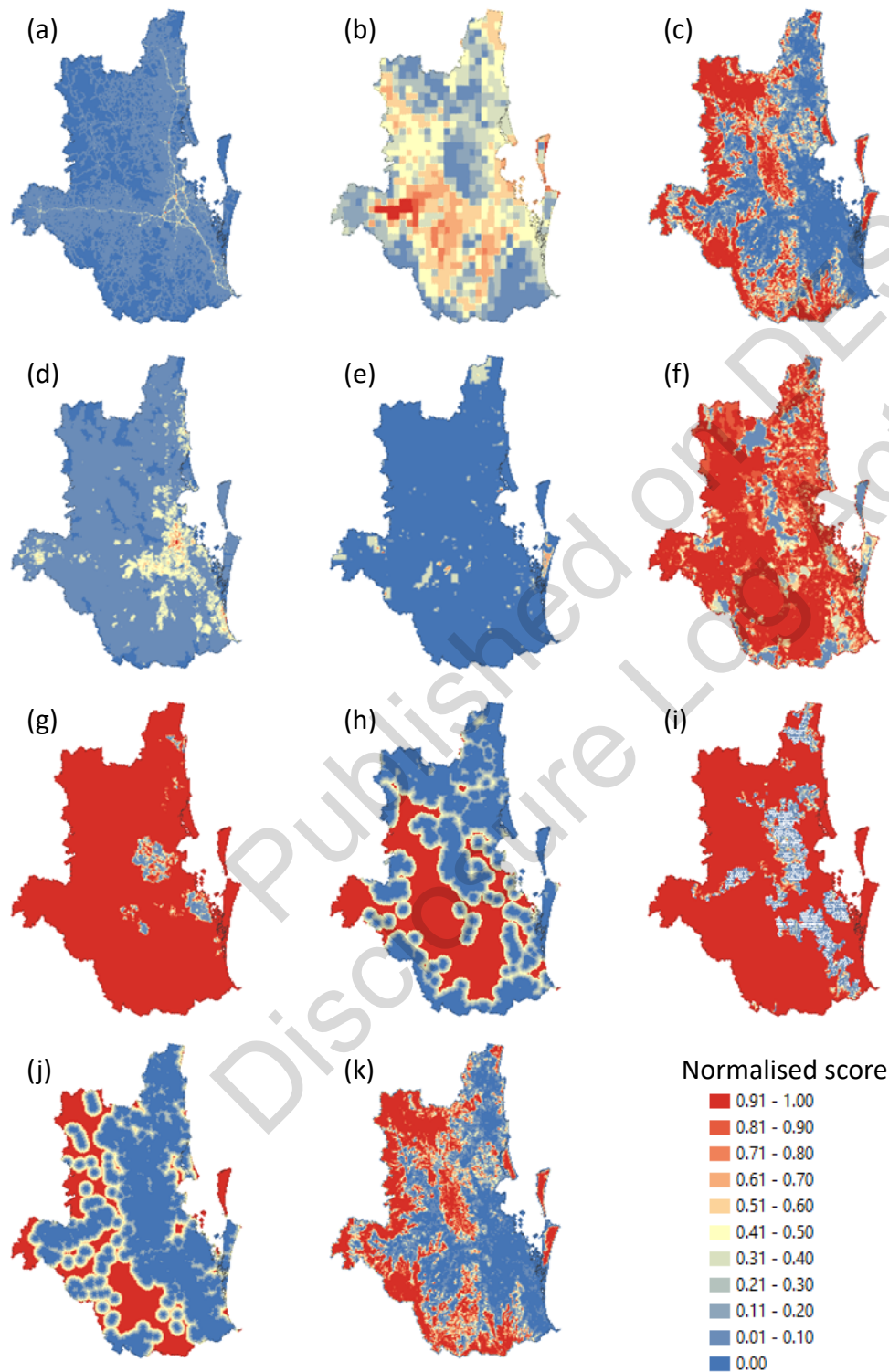


Figure 34: Koala habitat suitability categories for (a) pre-clearing and (b) remnant and regrowth.

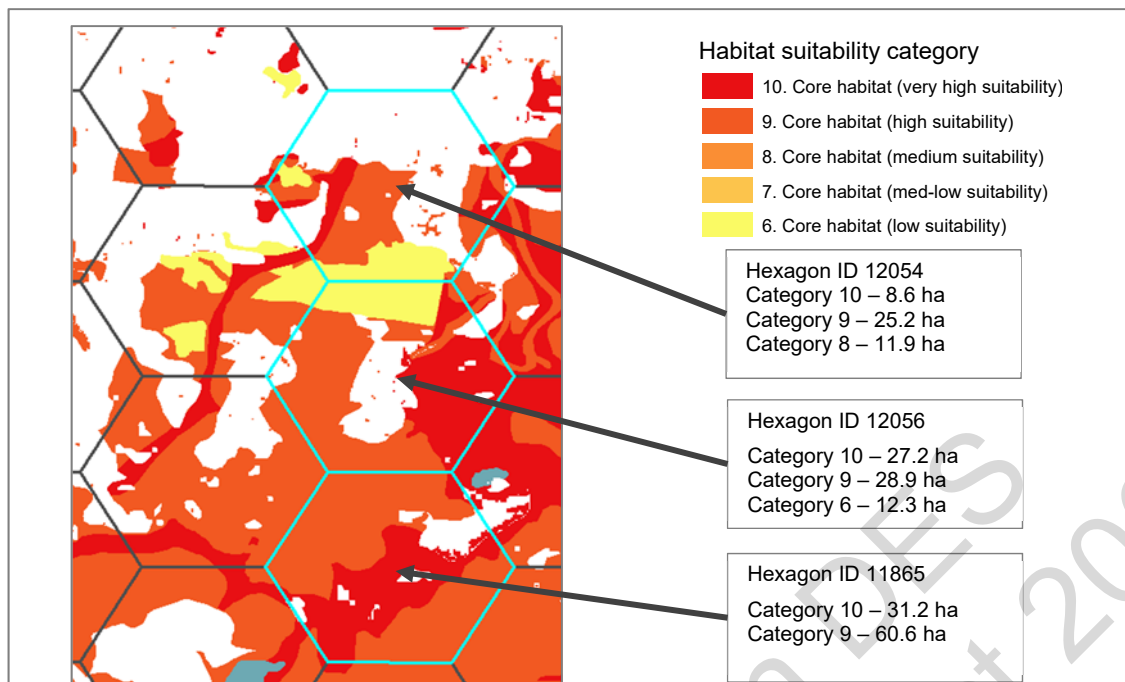
Appendix 10. Ecological cost layers

Individual maps of the spatial distribution of threats, constraints and opportunities used in the ecological cost layer for the chosen scenario. (a) Roads (R), (b) heat stress (P&R), (c) climate change (P&R), (d) urban development (P&R), (e) extractive industries (P&R), (f) conservation or environmental management areas (P&R), (g) bushland in KADA and PKADAs (P&R), (h) habitat within 5 km of protected areas (P), (i) restoration potential within 5 km of a KPA (R), (j) within 5 km of hexagon selection frequency for protection >20 (R), (k) climate change refugia (R). P = habitat protection, R = habitat restoration.

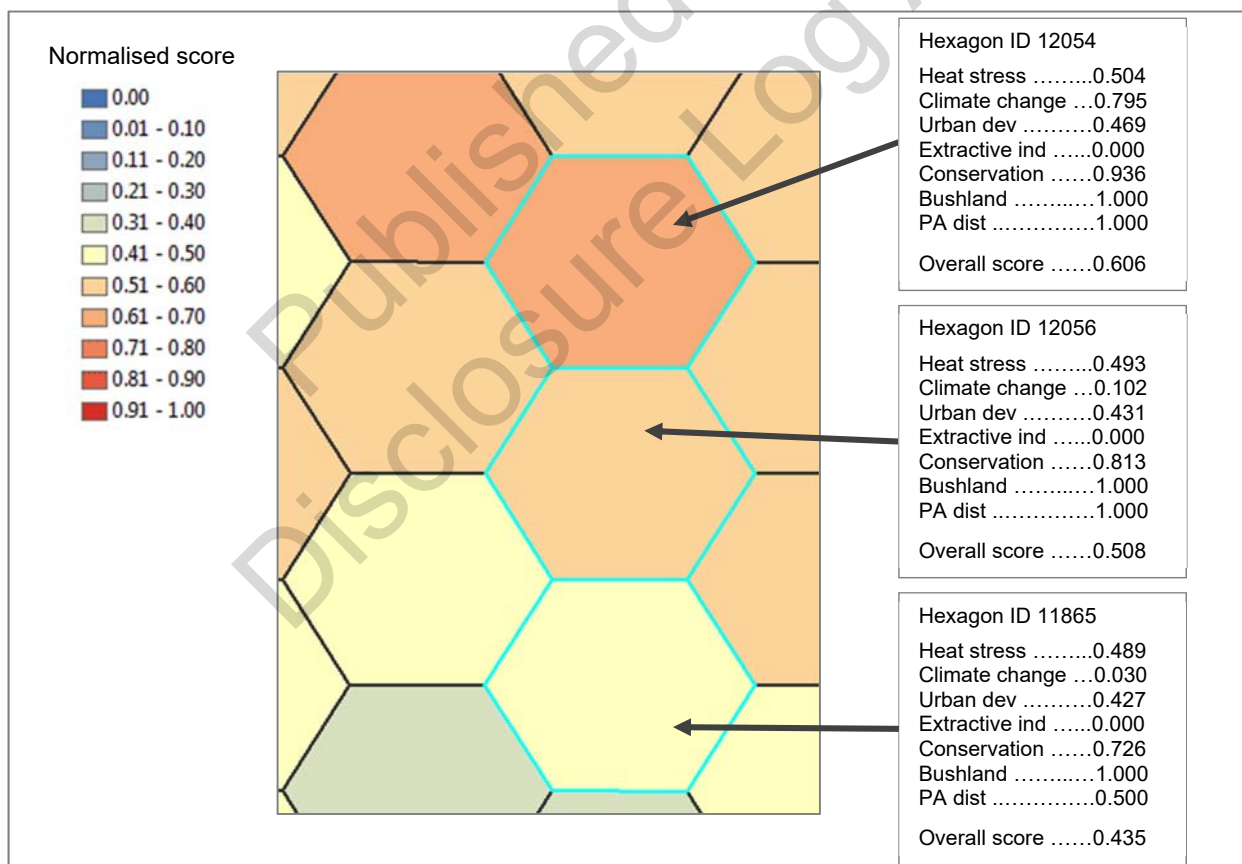


Appendix 11. Examples of Marxan target features and costs

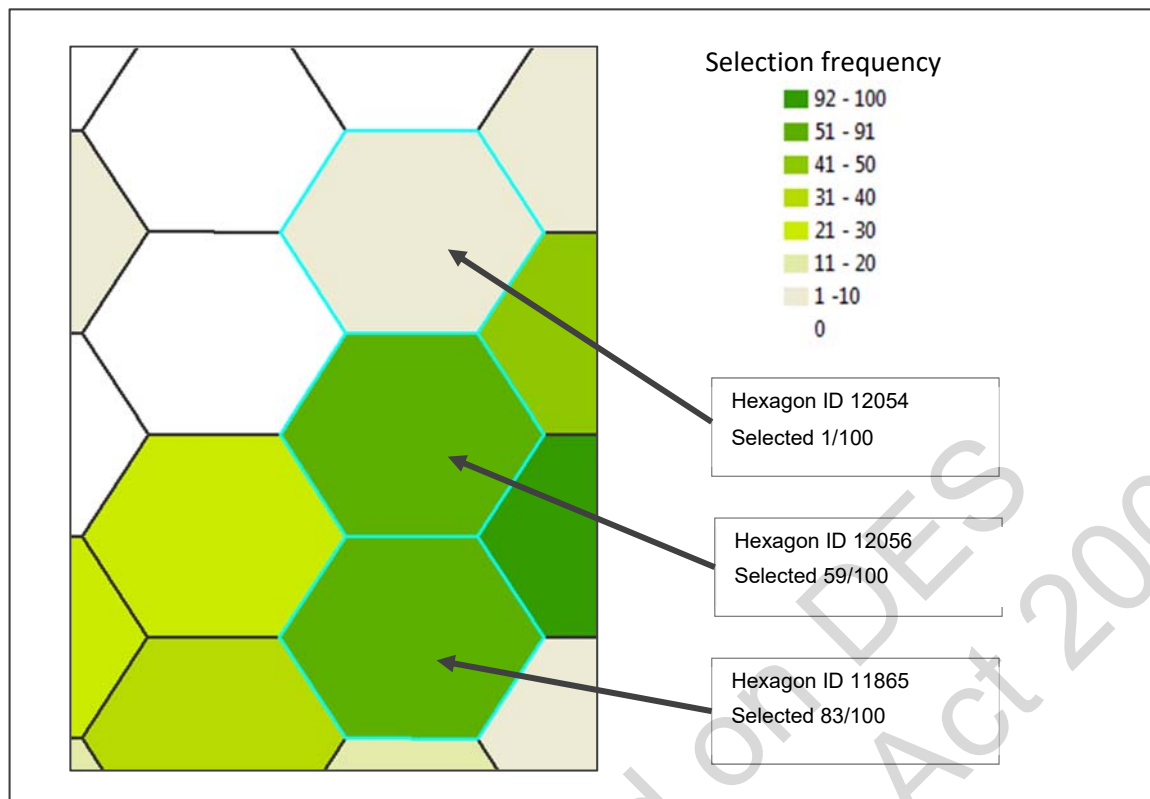
Example of calculating the target conservation features using the area of different habitat categories per hexagon.



Example of ecological cost calculation per hexagon. The scores for each variable are normalised. The overall score is the sum of the weighted threats, constraints and opportunities scores based on the weights in Table 2.



Example of Marxan output based on selection frequency for the chosen scenario. Hexagon 11865 was selected in 83 out of 100 runs, making it an important contributor because of its high area of habitat (total 91.7 ha out of 100 ha), and its lower ecological cost compared with hexagons 12054 and 12056.



Date : 3/10/2019 2:35:14 PM
From : "PERSHOUSE Audrey"
To : "DOWNES Mandy (DES)"
Cc : "HOPPER Karen" , "GEORGE Catherine"
Subject : RE: Pine Valley
Attachment : image003.png;image004.png;image006.png;image007.png;

Sorry Mandy,

I took that screenshot from the application's ecological assessment report. The dots and numbers are where the consultant says they surveyed.

The orange mapping is regulated vegetation under the VMA

Audrey Pershouse

Senior Policy Officer – Koala Policy and Oversight
Ph 3330 5487
Conservation Policy and Planning
Department of Environment and Science

From: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Sent: Thursday, 3 October 2019 2:11 PM
To: PERSHOUSE Audrey
Cc: HOPPER Karen; GEORGE Catherine
Subject: FW: Pine Valley

Audrey

Thanks for this, can you please advise what the green dots and numbers are referring to?

M



Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
Department of Environment and Science

P 07 3330 5818 : Ms) Personal in
Level 13, 400 George Street, Brisbane
GPO Box 2454, Brisbane 4001

From: HOPPER Karen <Karen.Hopper@des.qld.gov.au>
Sent: Wednesday, 2 October 2019 5:21 PM
To: DOWNES Mandy (DES)
Subject: FW: Pine Valley



Karen Hopper
Director
Conservation Policy and Planning Branch
Department of Environment and Science

P 07 3330 5174 Mobb) Personal in
Level 13, 400 George Street, Brisbane
GPO Box 2454, Brisbane 4001

From: PERSHOUSE Audrey
Sent: Wednesday, 2 October 2019 10:32 AM
To: GEORGE Catherine <Catherine.George@des.qld.gov.au>
Cc: HOPPER Karen <Karen.Hopper@des.qld.gov.au>
Subject: RE: Pine Valley

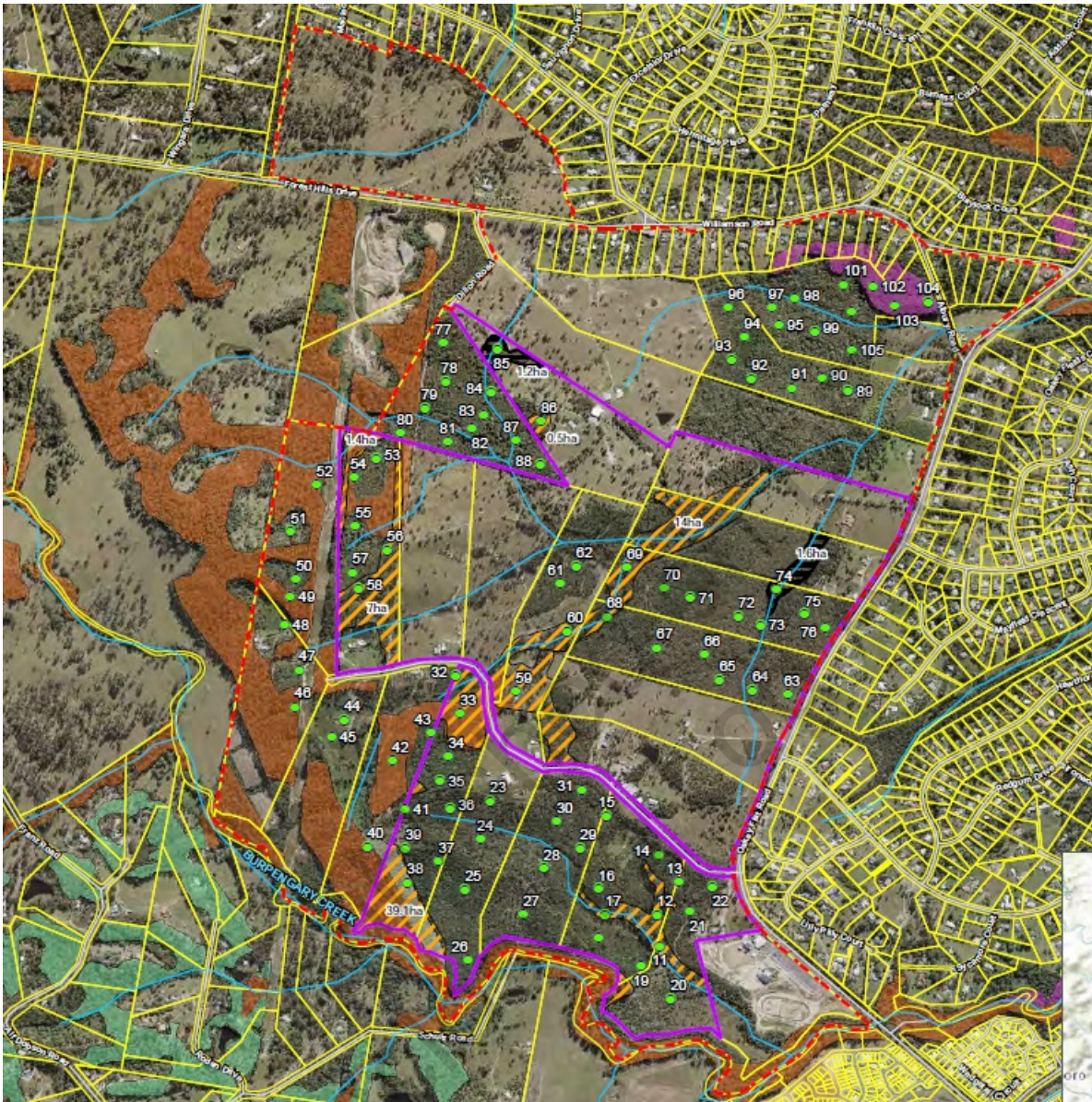
As we have communicated to Moreton Bay at the meetings, the transitional arrangements proposed will cover applications considered properly made but are awaiting decision, noting that if the application is refused or withdrawn, new applications will be subject to the new arrangements.

Pine Valley is a master planned area in the Moreton Bay LGA, according to the council's PD Online (their development application system), there is an existing development application for the area that Lend Lease own. Lend Lease are seeking a preliminary approval for a large

master planned community and have undertaken ecological assessment to review and remap the koala habitat on site. As their application is in process, the transitional arrangements will cover their application and allow it to continue to be assessed under the rules it was submitted under (they are in a Koala Assessable Development Area under the existing planning controls).

That said, Lend Lease do not own all of the properties in the council's Pine Valley master plan (see below image). Should there not be any applications submitted for those remaining blocks prior to commencement of the new provisions, then the remaining blocks will be subject to the new controls.

Red dotted outline is the master planned area. The purple outline is lend lease's application area.



Audrey Pershouse
Senior Policy Officer – Koala Policy and Oversight
Ph 3330 5487
Conservation Policy and Planning
Department of Environment and Science

From: GEORGE Catherine <Catherine.George@des.qld.gov.au>
Sent: Wednesday, 2 October 2019 8:52 AM
To: PERSHOUSE Audrey
Subject: FW: Pine Valley

Do you have any intel on Pine Valley? Dave is checking to see if it is in a KPA.

MBRC are raising concerns about transitional arrangements for the area.

c

From: HOPPER Karen <Karen.Hopper@des.qld.gov.au>

Sent: Tuesday, 1 October 2019 12:26 PM
To: GEORGE Catherine; DOWNES Mandy (DES); HOPPER Karen
Subject: Pine Valley

<https://communities.lendlease.com/queensland/pine-valley/-/media/communities/au/shared/documents/pine-valley/pine-valley-community-newsletter.pdf>

Shared via the [Google app](#)

Sent from my iPhone

Published on DES
Disclosure Log Act 2009

Date : 3/10/2019 3:52:26 PM
From : "DOWNES Mandy (DES)"
To : "GEORGE Catherine"
Cc : "PERSHOUSE Audrey" , "HOPPER Karen"
Subject : URGENT - Pine Valley - MBRC
Attachment : image001.png;image002.png;image003.jpg;image004.png;
Catherine,

Can you please advise the accuracy of the below ASAP please.

Thanks

M



Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
Department of Environment and Science

P 07 3330 5818 : M. Personal i
Level 13, 400 George Street, Brisbane
GPO Box 2454, Brisbane 4001

Hi Robyn

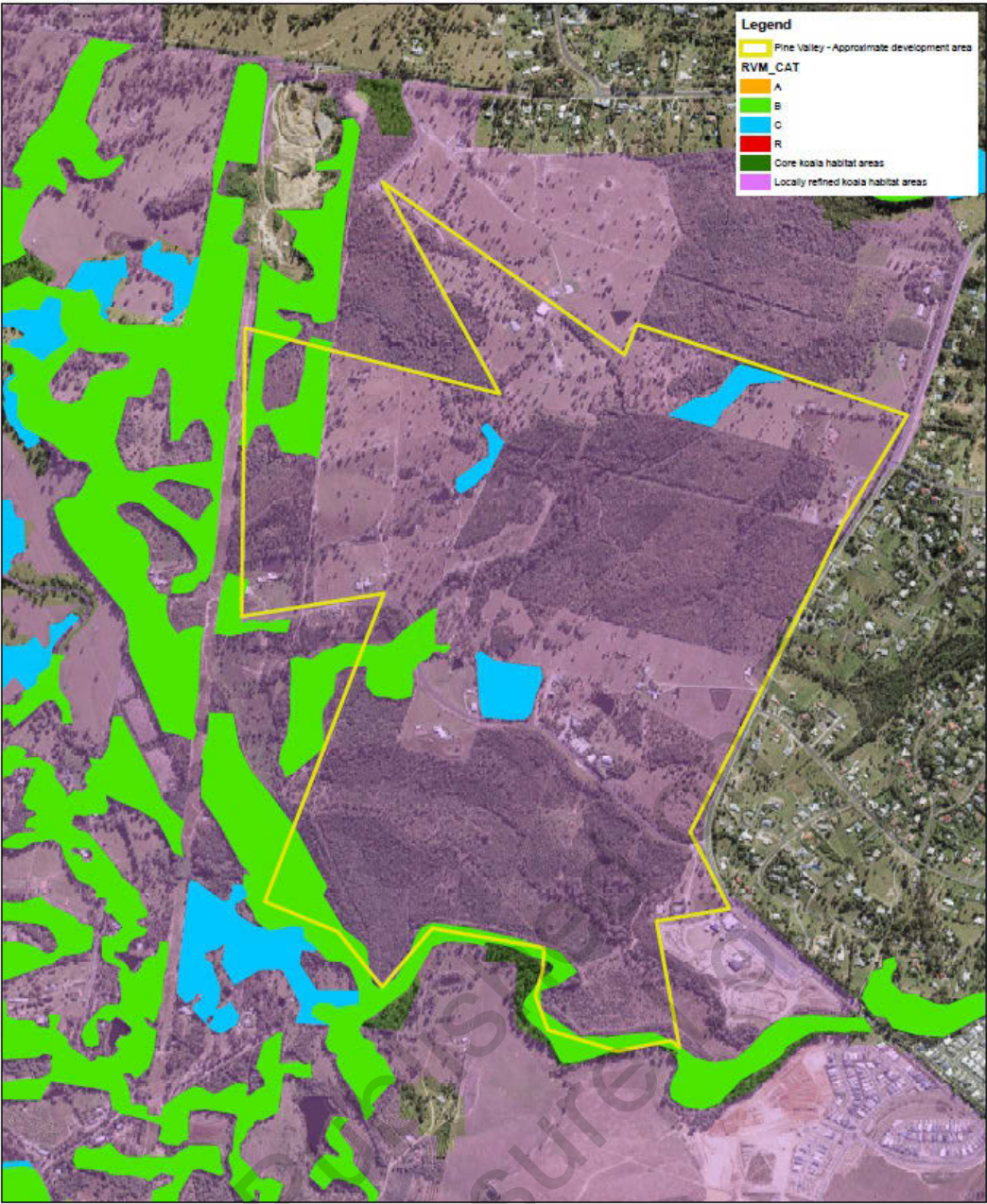
When we spoke on Tuesday, you sought clarification about the potential impacts mapping would have on the Pine Valley emerging community.

I understand that Pine Valley is a master planned area in the Moreton Bay LGA, and according to the council's PD Online, there is an existing development application for the area that Lend Lease own. Lend Lease are seeking a preliminary approval for a large master planned community and have undertaken ecological assessment to review and remap the koala habitat on site. As the application is in process, the transitional arrangements will cover their application and allow it to continue to be assessed under the rules it was submitted under (they are in a Koala Assessable Development Area under the existing planning controls). As we have previously advised, the transitional arrangements will cover applications considered properly made but are awaiting decision, noting that if the application is refused or withdrawn, new applications (submitted after the planning reforms are in place) will be subject to the new arrangements.

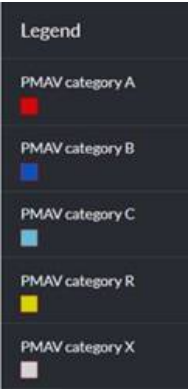
It is also noted that Lend Lease do not own all of the properties in the Pine Valley master plan. Should there not be any applications properly made for those remaining blocks prior to commencement of the new provisions, then the remaining blocks will be subject to the new reforms (if in place).

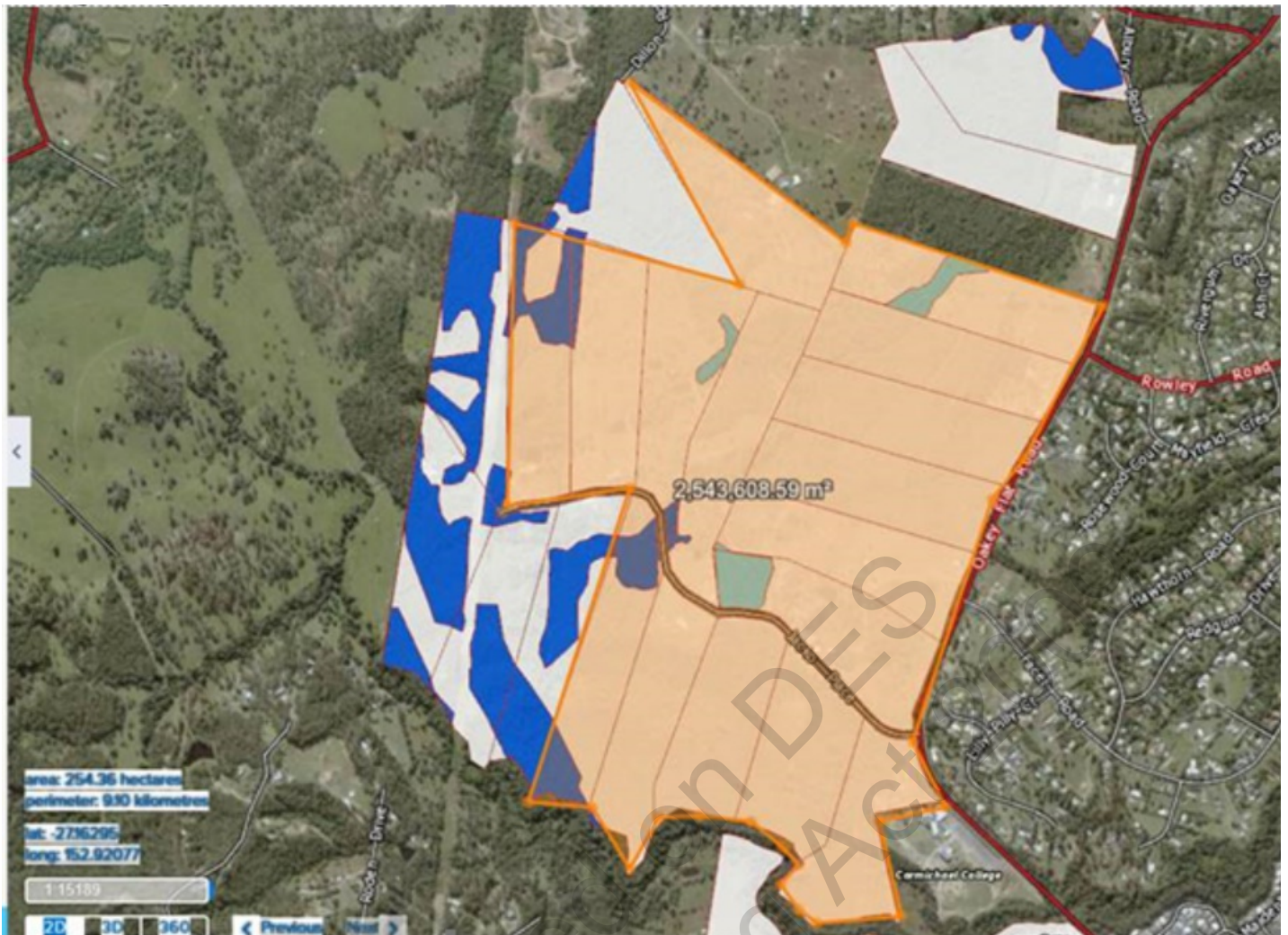
Based on the mapping you have received, you will see that locally refined koala habitat covers the majority of the area.

Pine Valley development area RVM on site - *boundary is approximate



Mapping of PMAVs over the area is as follows (orange area being the area subject to the development application:





As such, if the application has been properly made, it is assessed under the current framework. Any additional applications, subject to their timing for application, may be assessed against the new framework and category x will be treated as per 7 below.

I trust this clarifies.

Mandy



Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
 Department of Environment and Science

P 07 3330 5818 : M. Personal in
 Level 13, 400 George Street, Brisbane
 GPO Box 2454, Brisbane 4001

From: DOWNES Mandy (DES)

Sent: Tuesday, 1 October 2019 1:40 PM

To: Robyn Moffat

Cc: Kristy Gooding; 'Crystal Baker'; Environmental Services Mailbox; GEORGE Catherine; HOPPER Karen

Subject: RE: Request for clarification - Letter from Director General to MBRC

Hi Robyn,

Thanks for your time to talk through this today. As discussed, below is the written advice in response to each of your questions.

1. **The extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)]**

All types of bushland habitat (high, medium and low) has been included.

2. **Where will the above determined/defined mapping be applied?**

- **2.1 Across the whole MBRC region or**
- **2.2 Within the defined Koala Priority Area only**

Mapping is applied across the whole MBRC area. As discussed, the mapping will follow.

3. **What planning provisions/regulation apply to the mapped areas, within and outside the Koala Priority Area (including the transitional areas). I have attached the previously provided draft trigger tables and your advice regarding the application of these is appreciated.**

For consistency, the same provisions that apply to state mapping (i.e. prohibition in a KPA and avoid/mitigate/offset outside a KPA) will apply.

4. **Where is the defined (final version) Koala Priority Area boundary for the Moreton Bay region?**

Could you also provide, at your earliest convenience, shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping that will be applied across the Moreton Bay region and Koala Priority Area boundary so that we can load it into our GIS system for review (spatially).

Shape files will follow this email.

5. **Areas within the Moreton Bay region (growth areas/targets) that DES are aware of that will be impacted/influenced by the proposed mapping**

As discussed, this analysis is being undertaken by DSDMIP and we are awaiting the results.

6. **The intent of the proposed planning provisions and exemptions regarding mapped koala habitat, specifically -**

- **6.1 Development (within the Koala Priority Area) which purports to 'not require clearing of koala habitat', but approval of the development could result in subsequent clearing of koala habitat which is 'exempted development', will the (parent) development prohibited development?**

The prohibition applies to subdivisions (reconfiguring a lot) where, in creating new lots, koala habitat will need to be cleared.

Existing lots can utilise the exemptions, for example, to maintain their fence lines or create new ones that are considered necessary (e.g. a required pool fence).

The exemptions do not restrict the local government's plan making options should the vegetation meet a different MSES, or a local categorising instrument's MLES, nor do they prevent the application of a covenant or other vegetation protection mechanism should the assessment manager decide that it is reasonable and relevant for the development.

7. **What the proposed provisions/regulations would be in the following circumstance -**

A proponent has submitted an application to DNRM and have had their property assessed against the Vegetation Management Act 1999. The proponent has subsequently been provided with a PMAV that redefines the their lot as "Category X" under the Vegetation Management Act 1999. The lot also contains mapped koala habitat (MSES - GHD mapping - as per the Moreton Bay Regional Council Planning Scheme).

7.1 What are the koala habitat protection arrangements in this instance?

Clearing exemption for category x areas will only be allowed if the koala habitat is both core koala habitat area and category x as per the VMA.

7.2 Will the clearing of the koala habitat be prohibited?

To the extent that the category x area is a koala habitat area which is not core koala habitat, the clearing will be prohibited.

As requested, we will investigate the Pine Valley emerging community area and provide separate advice.

Thanks again for your time and please let me know if there is anything further you will require.

Regards

Mandy

Mandy Downes
A/Executive Director, Conservation Policy and Planning
Environmental Policy and Programs
 Department of Environment and Science



From: Robyn Moffat <Robyn.Moffat@moretonbay.qld.gov.au>
Sent: Monday, 30 September 2019 12:34 PM
To: DOWNES Mandy (DES); HOPPER Karen
Cc: Kristy Gooding; 'Crystal Baker'; Environmental Services Mailbox; GEORGE Catherine
Subject: RE: Request for clarification - Letter from Director General to MBRC
Importance: High

Hi Mandy and Karen,

Thank you Karen for your voice message last week confirming that a response was being prepared regarding Council's request for further information. Could you please provide an update at your earliest convenience.

In particular, Council's Director Planning & Economic Development, Mike Pickering is urgently waiting advice regarding the extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)] and the shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping and Koala Priority Area boundary that will be applied across the Moreton Bay region.

Thanks in advance and please do not hesitate to contact me if required.

Regards

Robyn Moffat
Manager, Environmental Services
Environmental Services Department
Moreton Bay Regional Council
PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: [\(6\) Personal info](#)
E: robyn.moffat@moretonbay.qld.gov.au

From: Robyn Moffat
Sent: Tuesday, 24 September 2019 4:16 PM
To: DOWNES Mandy (DES) <Mandy.Downes@des.qld.gov.au>
Cc: Kristy Gooding <Kristy.Gooding@lgaq.asn.au>; Crystal Baker <Crystal.Baker@lgaq.asn.au>
Subject: Request for clarification - Letter from Director General to MBRC

Hi Mandy,

In reference to the attached letter received by Council's Acting Chief Executive Officer, Graeme Kanofski could you please provide clarification on the below points. This will enable the team to update Directors and Councillors.

With reference to advice from the Director General that - "I have decided to include all existing koala habitat under the existing GHD mapping in order to ensure that more, rather than less, potential habitat is protected" could you please clarify:

1. The extent of the mapping that will be applied [i.e. Bushland Habitat (High, Medium, Low) + Suitable for rehab (High, Medium, Low)]
2. Where will the above determined/defined mapping be applied?
 - o 2.1 Across the whole MBRC region or
 - o 2.2 Within the defined Koala Priority Area only
3. What planning provisions/regulation apply to the mapped areas, within and outside the Koala Priority Area (including the transitional areas). I have attached the previously provided draft trigger tables and your advice regarding the application of these is appreciated.
4. Where is the defined (final version) Koala Priority Area boundary for the Moreton Bay region?

Could you also provide, at your earliest convenience, shapefiles (.shp, .shx, .dbf) of the proposed koala habitat mapping that will be applied across the Moreton Bay region and Koala Priority Area boundary so that we can load it into our GIS system for review (spatially).

With reference to the comment from the Director General that - "inclusion of these (mapped) areas may impact on achieving Shaping SEQ dwelling targets within MBRC.." could you please clarify:

5. Areas within the Moreton Bay region (growth areas/targets) that DES are aware of that will be impacted/influenced by the proposed mapping

6. The intent of the proposed planning provisions and exemptions regarding mapped koala habitat, specifically -

- o 6.1 Development (within the Koala Priority Area) which purports to 'not require clearing of koala habitat', but approval of the development could result in subsequent clearing of koala habitat which is 'exempted development', will the (parent) development prohibited development?

Examples for context -

A subdivision proposes a new lot boundary within 4m of koala habitat. The development claims the koala habitat will be retained by the proposal. A future landowner may be able to clear the koala habitat as it accords with the 'exempted development' criteria. Will the original subdivision proposal be considered to be prohibited development?

A lot reconfiguration 'does not require clearing of koala habitat' but results in 500m² lots which contain koala habitat. The koala habitat could subsequently be cleared as exempt clearing work (clearing of up to 500m² of koala habitat). Will the lot reconfiguration be considered to be prohibited development?

With reference to the comment from the Director General's that - "Exemptions were also drafted to align (wherever possible) to the corresponding exemptions under the State's Vegetation Management Framework to avoid unnecessary inconsistencies." could you please clarify:

7. What the proposed provisions/regulations would be in the following circumstance -

A proponent has submitted an application to DNRM and have had their property assessed against the *Vegetation Management Act 1999*. The proponent has subsequently been provided with a PMAV that redefines the their lot as "Category X" under the *Vegetation Management Act 1999*. The lot also contains mapped koala habitat (MSES - GHD mapping - as per the Moreton Bay Regional Council Planning Scheme).

7.1 What are the koala habitat protection arrangements in this instance?

7.2 Will the clearing of the koala habitat be prohibited?

Thank you for your advice. Please don't hesitate to give me a call should you require any further information or details regarding the above questions. I'll touch base with you later in the week.

Regards

Robyn Moffat
Manager, Environmental Services
Environmental Services Department
Moreton Bay Regional Council
PO Box 159, Caboolture Qld 4510
P: (07) 3480 6498
M: [6\) Personal info](#)
E: robyn.moffat@moretonbay.qld.gov.au

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