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Stand condition assessment of forests and woodlands of Barmah Forest — 2015

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Murray–Darling Basin Authority acknowledges and pays respect to the Traditional Owners, and their Nations, of the Murray–Darling Basin, who have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters. The MDBA understands the need for recognition of Traditional Owner knowledge and cultural values in natural resource management associated with the Basin.

The approach of Traditional Owners to caring for the natural landscape, including water, can be expressed in the words of the Northern Basin Aboriginal Nations Board:

> …As the First Nations peoples (Traditional Owners) we are the knowledge holders, connected to Country and with the cultural authority to share our knowledge. We offer perspectives to balance and challenge other voices and viewpoints. We aspire to owning and managing water to protect our totemic obligations, to carry out our way of life, and to teach our younger generations to maintain our connections and heritage through our law and customs. When Country is happy, our spirits are happy.

This report may contain photographs or quotes by Aboriginal people who have passed away. The use of terms 'Aboriginal' and 'Indigenous' reflects usage in different communities within the Murray–Darling Basin.

Cover image: Barmah Lake with water (photo by David Kleinert)

Acknowledgements

The Murray–Darling Basin Authority (MDBA) acknowledges the following monitoring service providers for their efforts in collecting, organising and providing ground survey data throughout The Living Murray icon sites that was used to validate the 2015 model outputs:

- GHD (Koondrook–Perricoota Forest)
- Murray–Darling Freshwater Research Centre (Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay–Mulcra–Wallpolla Islands)
- South Australian Department of Environment, Water and Natural Resources (Chowilla Floodplain).

The MDBA also acknowledges the contribution of staff from the following icon site management agencies for coordinating and assisting with the 2015 ground surveys:

- Goulburn Broken Catchment Management Authority (Barmah Forest)
- North Central Catchment Management Authority (Gunbower Forest)
- Forestry Corporation of New South Wales — Deniliquin (Koondrook–Perricoota Forest)
- Mallee Catchment Management Authority (Hattah Lakes and Lindsay–Mulcra–Wallpolla Islands)
- Department of Environment, Water and Natural Resources — Berri and Adelaide (Chowilla Floodplain).

The Living Murray stand condition assessment tool was developed by Shaun Cunningham, Peter Griffioen, Matt White and Ralph MacNally. The Murray–Darling Basin Authority would like to acknowledge the significant contribution made by Shaun Cunningham.

AAM Pty Ltd produced the RapidEye imagery mosaic used in this 2015 stand condition assessment, as well as previous years (2009–14).

The MDBA Geospatial Services Unit, specifically Md. Anisul Islam, undertook the modelling and mapping presented in this report.

The Living Murray environmental delivery, planning and monitoring team (MDBA), in particular Stuart Little and Katherine Tibbitts who produced this series of 2015 stand condition assessment reports on behalf of The Living Murray Initiative.

Contents

About this report

This report contains the results of an assessment of condition (health) of river red gum and black box forests and woodlands of Barmah Forest, a Living Murray icon site, in 2015. Condition is modelled by The Living Murray stand condition assessment tool (Cunningham, et al., 2014).

Tree condition assessments are also conducted at some icon sites. Readers should note that due to the differences in the methodologies, results from the stand condition assessment do not always correlate to results from the tree condition assessment. For example, stand condition assessments report the average of condition in a 0.25 ha (typically 50 x 50 m) plots while tree condition assessment reports the proportion of trees within transects (n=30 trees per transect) that are in specific condition classes (e.g. % above the ecological target, or % that trigger the management threshold).

The extent of forests and woodlands shown in this report are based on spatial information held by the Murray–Darling Basin Authority (MDBA) Geospatial Services Unit.

Introduction

To provide a consistent assessment of river red gum and black box condition across The Living Murray icon sites, the MDBA provided funding to develop The Living Murray stand condition assessment tool.

The stand condition assessment tool (Cunningham, et al., 2014) uses the relationship between ground surveys of stand condition at monitoring sites and remotely sensed data to predict stand condition across the spatial extent of the icon sites that support river red gum and black box populations, namely:

- Barmah–Millewa Forest
- Gunbower, Koondrook–Perricoota Forests
- Hattah Lakes
- Lindsay–Mulcra–Wallpolla Islands
- Chowilla Floodplain
- River Murray Channel.

Stand condition scores as predicted by the model are then mapped across the various forest types and categorised into the following stand condition classes:

- good
- moderate
- poor
- degraded
- severely degraded.

The areas of each vegetation type in each condition class within each icon site are then reported for each year the assessment has been conducted.

The results from the stand condition assessment can then be used to inform the progress towards, or away from, the ecological targets relevant to icon site river red gum and black box condition (health) objectives.

Methods

Stand condition modelling

The stand condition assessment tool (the assessment tool) uses the multi-year model developed by Cunningham, et al. (2014) to model stand condition of The Living Murray icon sites for a given year. The assessment tool calculates the stand condition map from reflectance values derived from RapidEye satellite imagery and a range of spatial variables used to model stand condition. For further information about the assessment tool methodology see Cunningham, et al. (2014).

The RapidEye imagery mosaic for the 2015 stand condition assessment was prepared using RapidEye imagery captured between January and April 2015. The assessment tool was supplied with the mosaic's five spectral bands and run as per the methods outlined in Cunningham & Griffioen (2013).

The assessment tool calculated stand condition from the input variables provided and produced the raster file of 2015 stand condition scores to be viewed and analysed in ArcGIS (ESRI, Redlands, California).

Validation of model outputs

In order to determine how well the model has predicted stand condition, a validation survey of stand condition using ground-based assessments is undertaken. The validation data provide field observations of stand condition at specific field locations.

The validation feature of the assessment tool allows the checking of the map predictions against the field observations and if necessary adjust the predictions according to the relationship between the surveyed and predicted values.

One hundred and fifty field locations were assessed across all of the icon sites between January and April 2015 as per the methods outlined in *Ground-based survey methods for The Living Murray assessment of condition of river red gum and black box populations* (MDBA, 2012). Field validation sites were selected in 2009 by Cunningham et al. (2009). Sites were chosen to be representative of the range of forest types, forest condition and landscape positions (e.g. riverine, wetland and floodplain) at each icon site.

The field validation data was input to the assessment tool and correlated to the initial modelled values. The accuracy of the model's predictions of condition were assessed by determining if the linear fit (i.e. the correlation value) was >0.77 (which equates to an R^2>0.6).

Confirmation that the R^2>0.6, does not necessarily mean the model is predicting the observed values accurately. Therefore, additional tests are applied to determine if:

- the offset (i.e. the regression intercept) is between -1 and +1
- the scalar (i.e. the regression slope) is between 0.8 and 1.2.

If the offset or scalar values are outside of the ranges outlined above, the predicted stand condition values do not correlate well with field observations and would benefit from a post-process adjustment (using an inverse-linear regression) being applied (Cunningham, et al., 2014).

Map analysis

Maps of the stand condition assessments are produced for The Living Murray icon sites using ArcGIS. The assessment tool predicts a stand condition score that is based on the variables: percentage live basal area; plant area index; and crown extent. Values of the stand condition score range between 0 (dead) to 10 (excellent condition).

For reporting purposes, the maps are then classified into five condition classes: good, moderate, poor, degraded and severely degraded (see Table 1) using ArcGIS.

Table 1: Classification of stand condition score to condition categories.

Stand condition score range	Condition category
>8 to 10	good
>6 to 8	moderate
>4 to 6	poor
>2 to 4	degraded
0 to 2	severely degraded

To enable reporting of stand condition for the various forest and woodland types that exist within The Living Murray icon sites, distribution maps were created for the following six forest types:

- river red gum forest — stands dominated by *Eucalyptus camaldulensis* with 30–45% projective foliage cover[1]
- river red gum woodland — stands dominated by *E. camaldulensis* with 20–25% projective foliage cover
- river red gum/black box woodland — mixed stand of *E. camaldulensis* and *E. largiflorens*
- black box woodland — stands dominated by *E. largiflorens*
- river red gum/box woodland — stands dominated by *E. camaldulensis*, *E. largiflorens* and *E. microcarpa* included in Millewa and Koondrook–Perricoota forests only
- box woodland — stands dominated by *E. largiflorens* and *E. microcarpa* included in Millewa and Koondrook–Perricoota forests only.

Distribution maps were developed from the sources described in Table 2. The forest type distribution for Barmah Forest is presented in Map 1.

Proportions and area (in hectares) of each forest type in each condition class were then determined from the attribute table of the stand condition shapefile and reported in the results section of this report.[2]

[1] Projective foliage cover is the percentage of ground area occupied by the vertical projection of the foliage of woody vegetation.
[2] Total areas for each icon site and forest type provided in the results section may vary slightly between assessments due to data transformation and combining vector data (forest types) and raster data (stand condition).

Table 2: Information sources used to map forest type distribution (from Cunningham et al. (2009)

Region	Map	Source
Barmah Forest	Ecological vegetation community (EVC)	Dept. Sustainability and Environment (Victoria)
	State forest resource inventory (SFRI)	Dept. Sustainability and Environment (Victoria)
Millewa Forest	State Forest NSW map	Forests NSW
Gunbower Island	Ecological vegetation community (EVC)	Dept. Sustainability and Environment (Victoria)
	State Forest Resource Inventory (SFRI)	Dept. Sustainability and Environment (Victoria)
Koondrook & Perricoota	State Forest NSW map	Forests NSW
Hattah Lakes	Ecological vegetation community (EVC)	Dept. Sustainability and Environment (Victoria)
	State forest resource inventory (SFRI)	Dept. Sustainability and Environment (Victoria)
Lindsay–Mulcra–Wallpolla Islands	Ecological vegetation community (EVC)	Dept. Sustainability and Environment (Victoria)
	State forest resource inventory (SFRI)	Dept. Sustainability and Environment (Victoria)
Chowilla Floodplain	Vegetation of Chowilla floodplain	CSIRO Land and Water
River Murray Channel (NSW and SA)	Riparian vegetation of the River Murray	Murray–Darling Basin Commission — Margules and others
River Murray Channel (Vic)	Ecological vegetation community (EVC)	Dept. Sustainability and Environment (Victoria)

Results

Model validation and correction

The initial model predictions of stand condition scores for 2015 were highly correlated (R^2=0.79) with the observations from the field validation surveys across the icon sites. However, the offset (regression intercept) and the scalar (regression slope) of the validation relationship indicated that the initial scores under-represented the number of good condition and degraded condition sites. This result is similar to stand condition assessments in previous years (Cunningham, et al., 2014; Cunninhgam, et al., 2011; Cunningham, et al., 2009).

Therefore, as per the method outlined in Cunningham and Griffioen (2013) an adjustment was applied to the initial stand condition scores to improve the accuracy at the extreme ends of the condition spectrum. The correlation between the adjusted stand condition scores and field observations from the validation surveys is presented in Figure 1 and Figure 2.

It is noted that in conducting this assessment at the whole of The Living Murray scale (i.e. 14,037 km^2) across years and different forest types, a perfect match between field observations and stand condition scores at the pixel scale (0.000625 km^2) does not always occur.

The correlation between model predictions and observations from the field shows that whilst different forest types have differing levels of accuracy at the pixel scale, the 2015 stand condition assessment provides whole of icon site information on stand condition that is highly correlated with field observations. These results are suitable for informing the progress towards, or away from, the ecological targets relevant to icon site river red gum and black box condition.

The adjusted stand condition scores, classified into stand condition classes per Table 1, have been used to produce the statistics and mapping presented in this report.

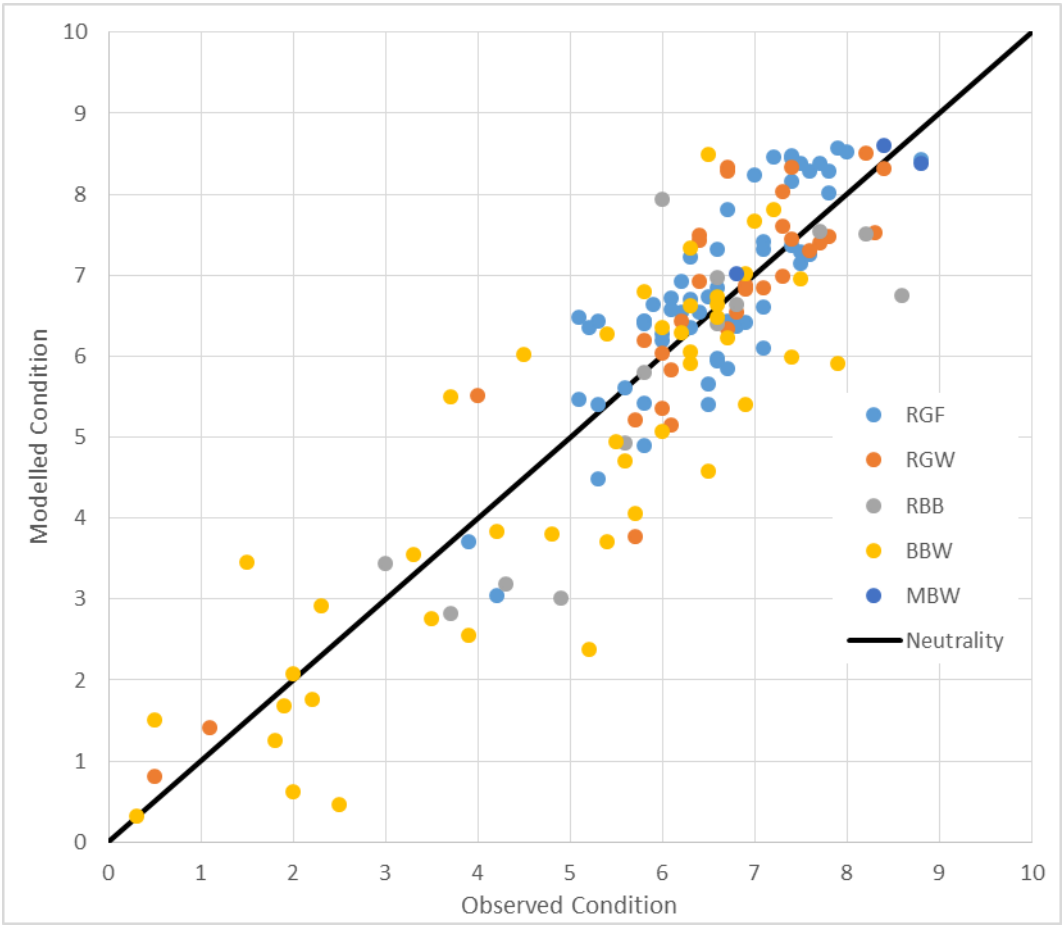
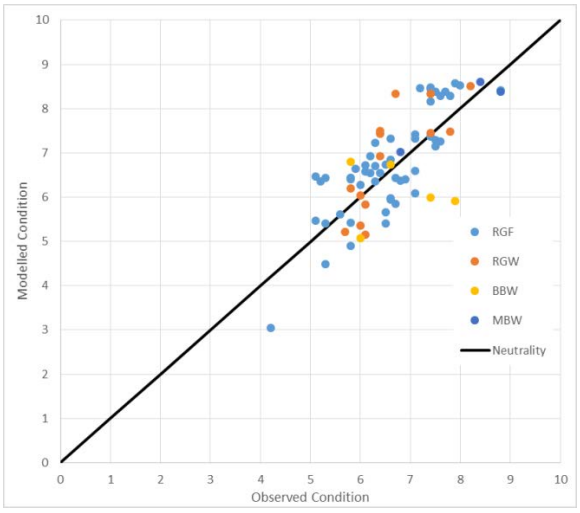


Figure 1: Relationship between predicted and observed condition and for 150 validation sites across all The Living Murray icon sites. Forest types are black box woodland (BBW), mixed box woodlands (MBW), mixed river red gum and black box woodlands (RBB), river red gum forests (RGF) and river red gum woodlands (RGW).

a)



b)

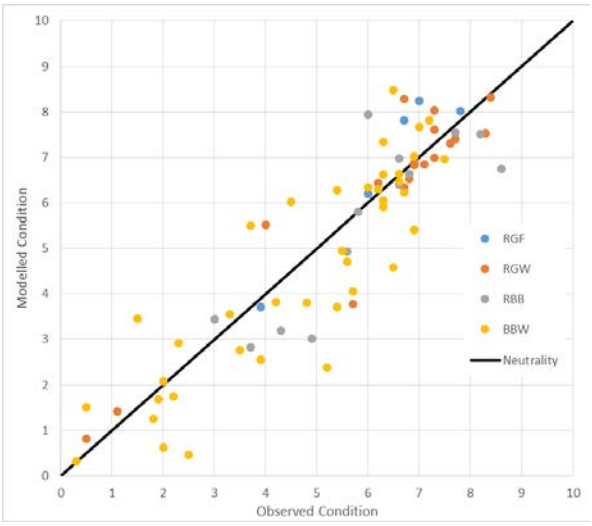


Figure 2: Relationship between predicted and observed condition for validation sites in the riverina (*n*=75) (a) and mallee (*n*=75) (b) bioregions. Forest types are black box woodland (BBW), mixed box woodlands (MBW), mixed river red gum and black box woodlands (RBB), river red gum forests (RGF) and river red gum woodlands (RGW).

Stand condition assessment

Table 3 provides the results of the 2015 stand condition assessment for Barmah Forest. Spatial extent of each condition class is presented in Map 2.

In 2015, 31.7% of the forests and woodlands of Barmah Forest are considered to be in good condition. An additional 64.3% of the forests are considered to be in moderate condition. The remaining areas of floodplain forests are considered to be in poor, degraded or severely degraded condition — the area in these condition classes is only 4.0%, about 1,048 ha.

Table 3: Percentage of the total forest and woodland and estimated area within Barmah Forest in each condition class in 2015 as predicted by the stand condition assessment tool

Category	Good	Moderate	Poor	Degraded	Severely degraded
% of forest area in each condition class	31.7	64.3	3.5	0.4	0.1
Estimated area in hectares (ha)	8,265	16,766	925	97	26

Historical comparisons of icon site proportions in each stand condition class are provided in Table 4.

Table 4: Historical comparison of the percentage of the total forest and woodland and estimated area within Barmah Forest in each condition class as predicted by the stand condition assessment tool

Year	Good	Moderate	Poor	Degraded	Severely degraded
% of forest area 2009	32.9	64.6	2.3	0	0.1
% of forest area 2010	29.3	65.2	4.8	0.6	0.1
% of forest area 2011	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
% of forest area 2012	37.8	59.5	2.4	0.3	0.1
% of forest area 2013	33.3	64.0	2.4	0.1	0.1
% of forest area 2014	37.6	59.7	2.4	0.1	0.1
% of forest area 2015	31.7	64.3	3.5	0.4	0.1
Estimated area (ha) 2009	8,575	16,859	612	8	25
Estimated area (ha) 2010	7,634	17,013	1,249	158	27
Estimated area (ha) 2011	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Estimated area (ha) 2012	9,858	15,508	617	70	26
Estimated area (ha) 2013	8,694	16,701	625	34	25
Estimated area (ha) 2014	9,812	15,577	633	33	26
Estimated area (ha) 2015	8,265	16,766	925	97	26

The stand condition assessment results for each forest type within Barmah Forest are presented in Table 5.

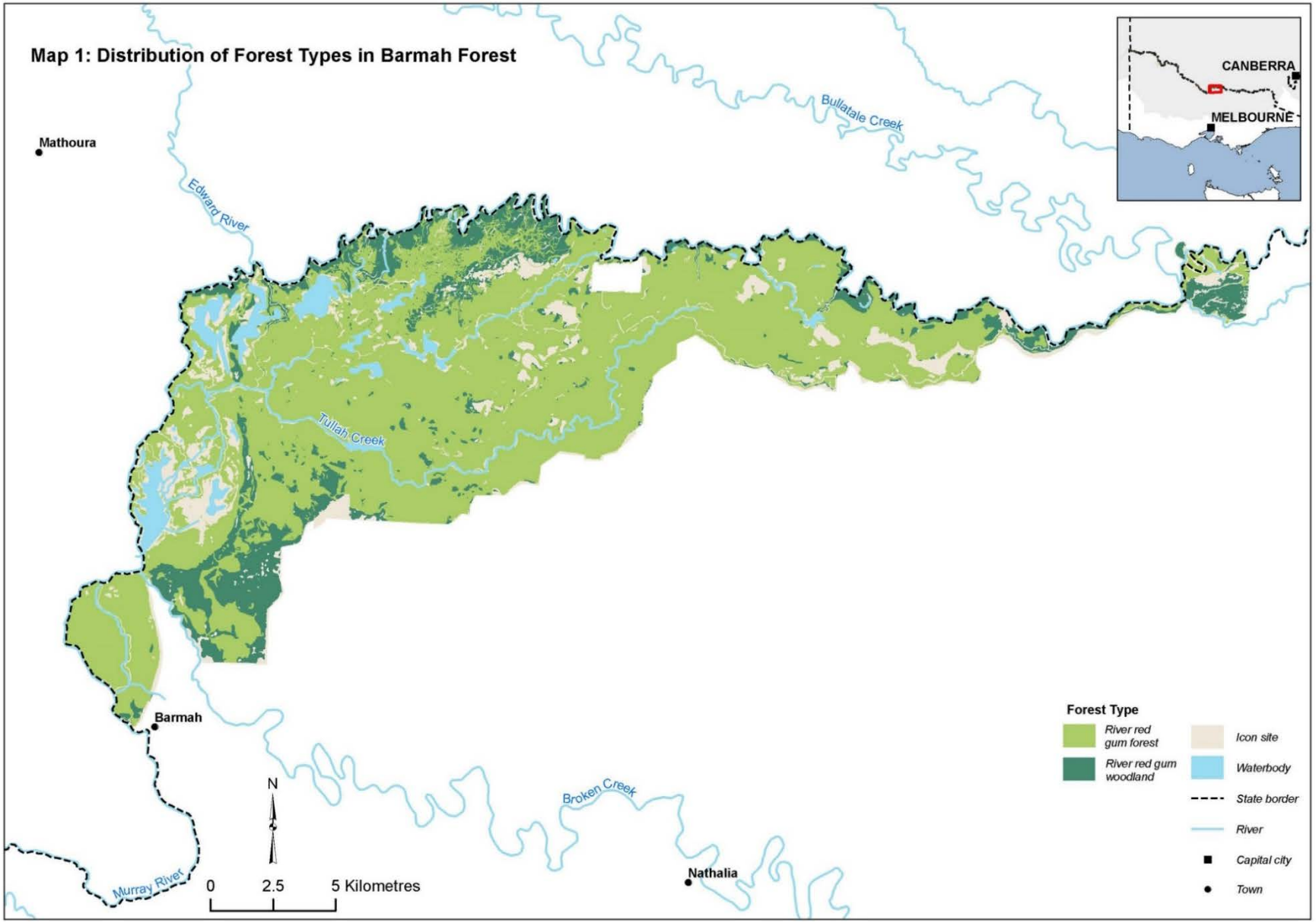
Spatial extents of each condition class, within each forest type are presented in Maps 3 and 4. Stand condition assessment results for previous years are provided in Appendix 1.

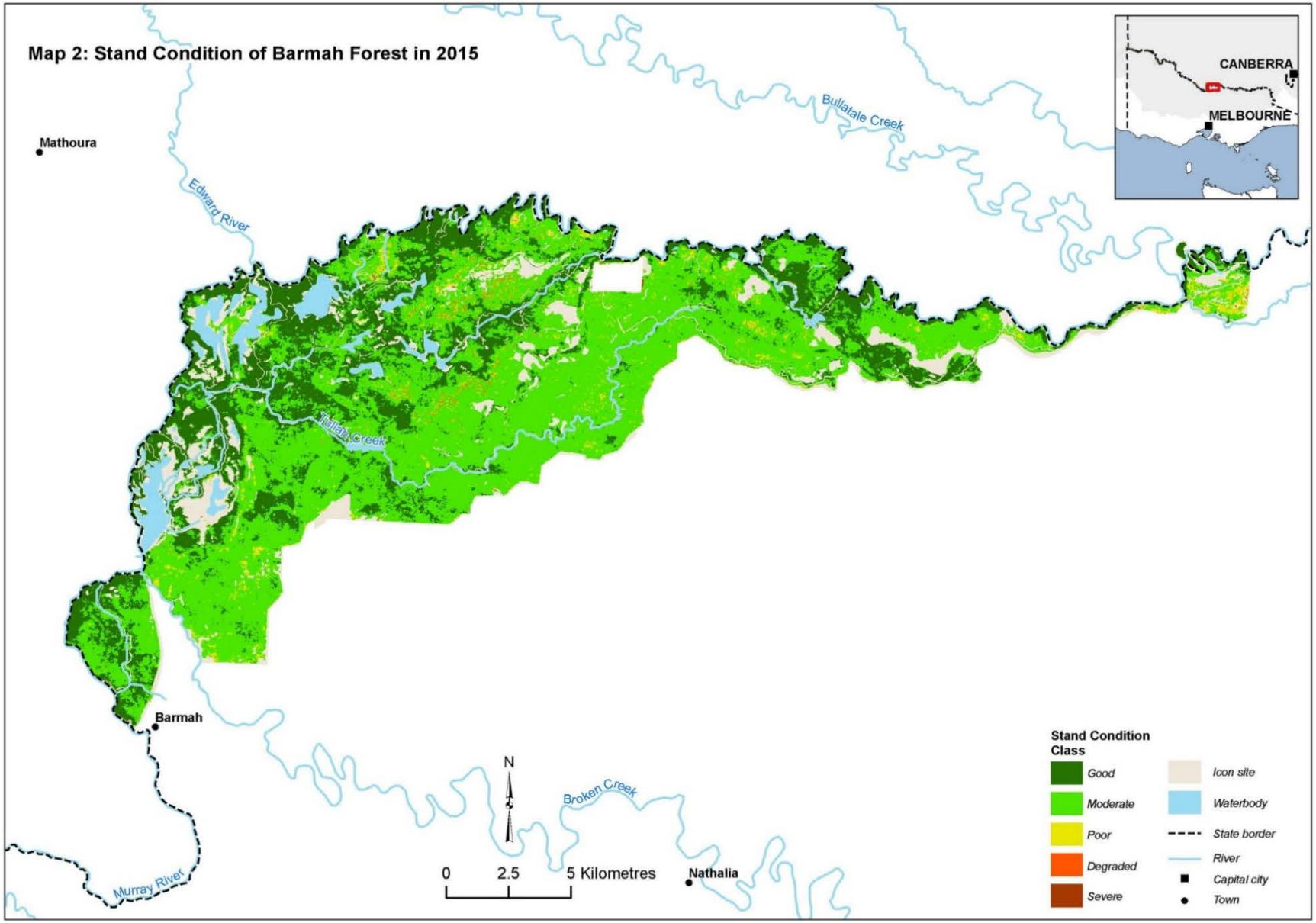
River red gum forest has the largest extent of good condition stands with 33.1% of the area of these forests predicted to be in good condition. The remaining areas are predominantly in moderate condition, with only 2.9% (622 ha) of the entire river red gum forest area considered to be in poor, degraded or severely degraded condition.

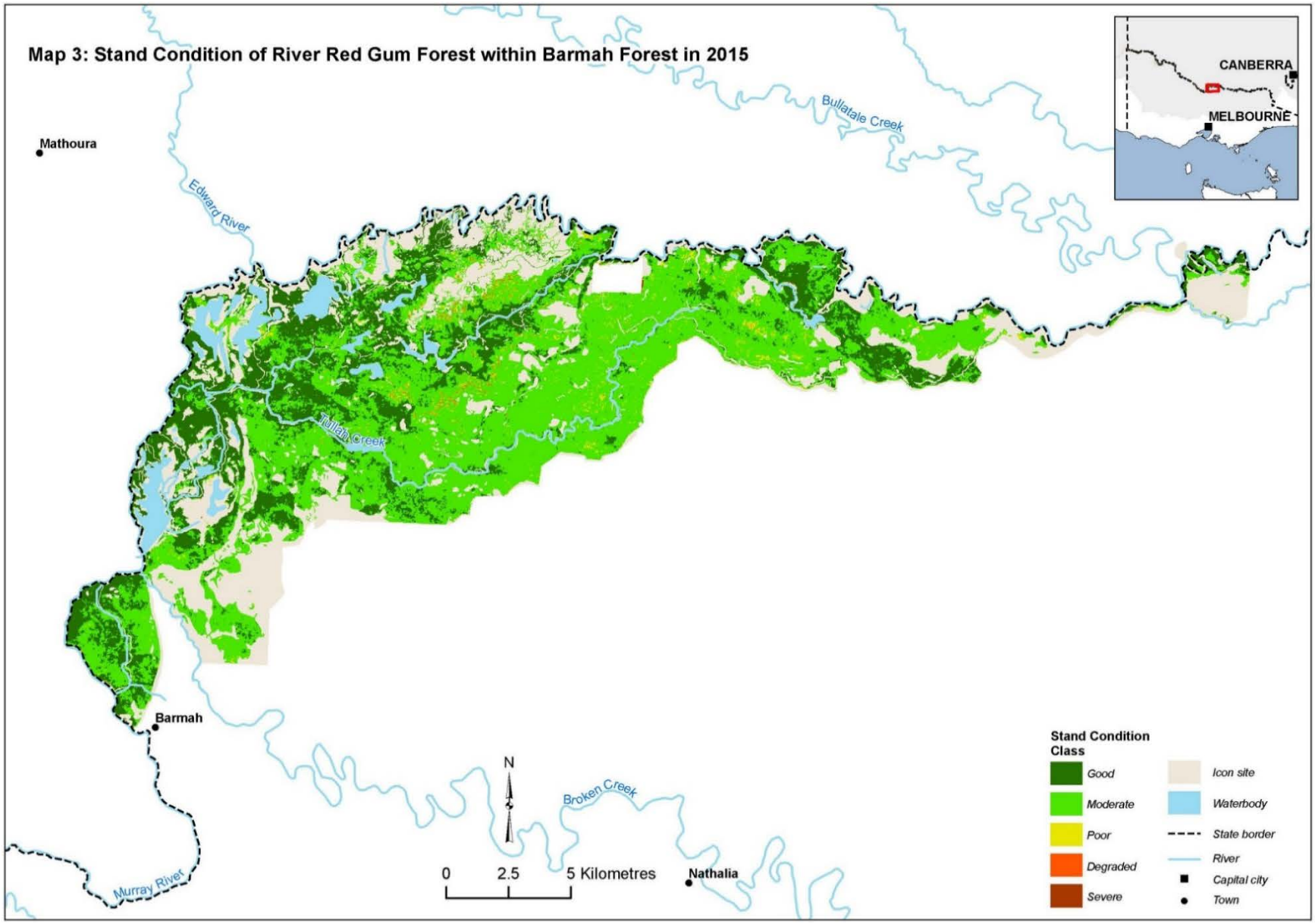
River red gum woodlands show a similar pattern to river red gum forests with 24.1% of the area of river red gum woodlands considered in good condition and a further 65.8% predicted to be in moderate condition. 10.1% (426 ha) of the river red gum woodlands are predicted to be in poor, degraded or severely degraded condition.

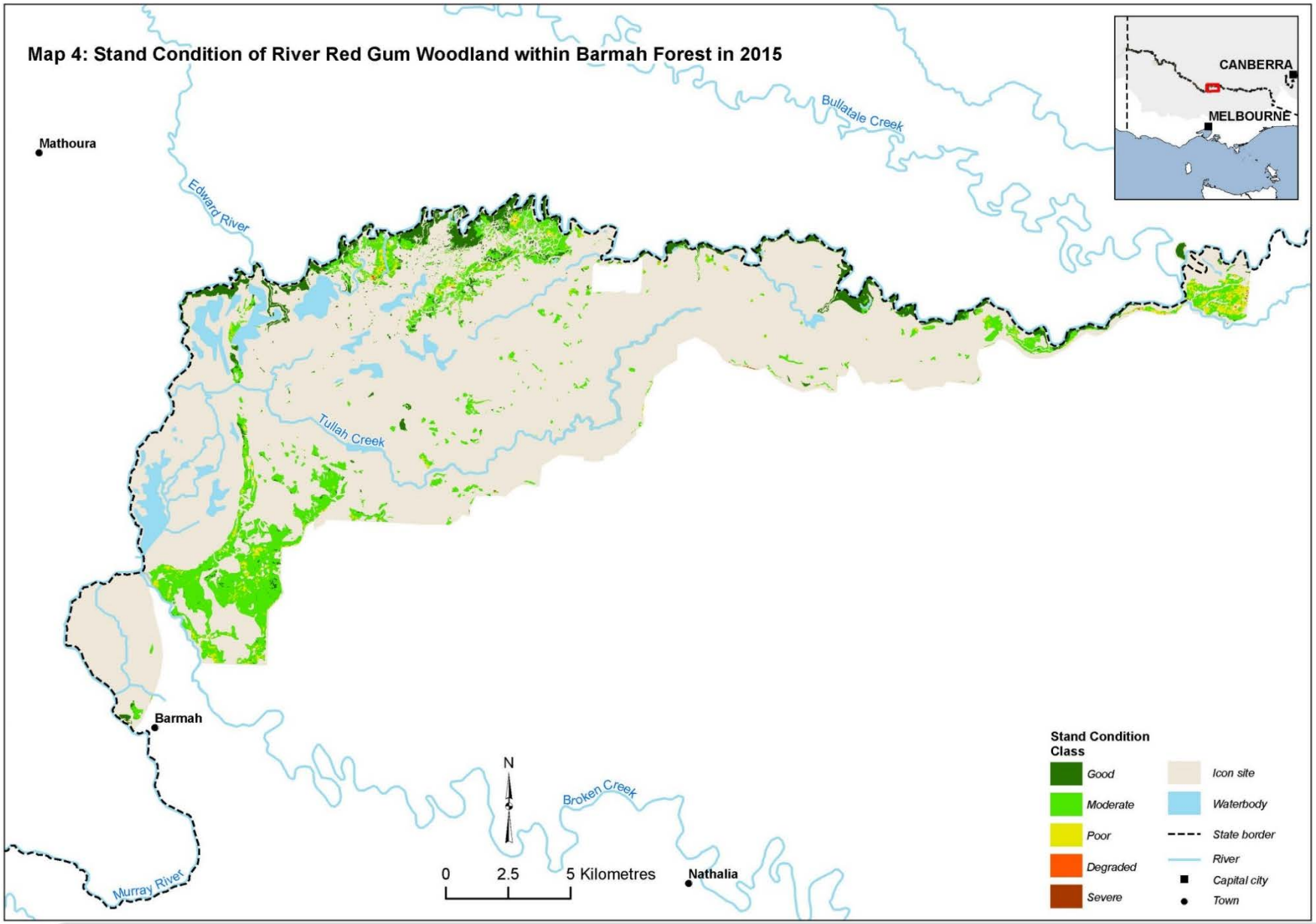
Table 5: Proportion and estimated area of each forest type in each condition class in 2015 as predicted by the stand condition assessment tool

Category	Good	Moderate	Poor	Degraded	Severely degraded
% of river red gum forest area	33.1	64	2.4	0.4	0.1
% of river red gum woodland area	24.1	65.8	9.5	0.3	0.3
Estimated area of river red gum forest (ha)	7,245	13,982	523	84	15
Estimated area of river red gum woodland (ha)	1,020	2,784	402	13	11


Map 1: Distribution of Forest Types in Barmah Forest
Mathoura
Edward River
Bullatale Creek
Tullah Creek
Barmah
Broken Creek
Murray River
Nathalia
N
0
2.5
5 Kilometres
CANBERRA
MELBOURNE
Forest Type
River red gum forest
River red gum woodland
Icon site
Waterbody
State border
River
Capital city
Town


Map 2: Stand Condition of Barmah Forest in 2015
Mathoura
Edward River
Bullatale Creek
Tullah Creek
Barmah
Broken Creek
Murray River
Nathalia
N
0
2.5
5 Kilometres
CANBERRA
MELBOURNE
Stand Condition Class
Good
Moderate
Poor
Degraded
Severe
Icon site
Waterbody
State border
River
Capital city
Town


Map 3: Stand Condition of River Red Gum Forest within Barmah Forest in 2015
Mathoura
Edward River
Bullatale Creek
Tullah Creek
Barmah
Broken Creek
Murray River
Nathalia
N
0
2.5
5 Kilometres
CANBERRA
MELBOURNE
Stand Condition Class
Good
Moderate
Poor
Degraded
Severe
Icon site
Waterbody
State border
River
Capital city
Town


Map 4: Stand Condition of River Red Gum Woodland within Barmah Forest in 2015
Mathoura
Edward River
Bullatale Creek
Tullah Creek
Barmah
Broken Creek
Murray River
Nathalia
N
0
2.5
5 Kilometres
CANBERRA
MELBOURNE
Stand Condition Class
Good
Moderate
Poor
Degraded
Severe
Icon site
Waterbody
State border
River
Capital city
Town

Further information

The following spatial data are available by forwarding a request to gis@mdba.gov.au:

- forest type mapping used in The Living Murray stand condition assessment
- stand condition assessment maps for all years (2009, 2010, 2012–15).

All products can be supplied as whole of The Living Murray (i.e. icon sites including the River Murray Channel) or clipped to areas of interest (where specifications are provided within the data request).

For further details on the validation of model results, RapidEye imagery used in the assessment or any other questions on the stand condition assessment please email TLMMonitoring@mdba.gov.au.

References

Cunningham, S. & Griffioen, P., 2013. *Murray Stand Condition Tool User's Guide,* Canberra: Murray–Darling Basin Authority.

Cunningham, S., Griffioen, P., White, M. & Mac Nally, R., 2014. *A Tool for Mapping Stand Condition across the Floodplain Forests of The Living Murray Icon Sites,* Canberra: Murray–Darling Basin Authority.

Cunningham, S., Mac Nally, R., Griffioen, P. & White, M., 2009. *Mapping the Condition of River Red Gum and Black Box Stands in The Living Murray Icon Sites. A Milestone Report to the Murray–Darling Basin Authority as part of Contract MD1114.,* Canberra: Murray–Darling Basin Authority.

Cunninhgam, S., Griffioen, P., White, M. & Mac Nally, R., 2011. *Mapping the Condition of River Red Gum (Eucalyptus camaldulensis Dehnh.) and Black Box (Eucalyptus largiflorens F.Muell.) Stands in The Living Murray Icon Sites. Stand Condition Report 2010.,* Canberra: Murray–Darling Basin Authority.

MDBA, 2012. *Ground-based survey methods for The Living Murray assessment of condition of river red gum and black box populations,* Canberra: Murray–Darling Basin Authority.

Appendix 1

Stand condition assessment results for Barmah Forest — 2009 to 2015

Table A1: River red gum forest.

Year	Area in condition class (ha)					Proportion in condition class (%)				
	Good	Moderate	Poor	Degraded	Severely degraded	Good	Moderate	Poor	Degraded	Severely degraded
2009	7,506	13,957	367	5	14	34.4	63.9	1.7	0	0.1
2010	6,659	14261	777	137	15	30.5	65.3	3.6	0.6	0.1
2011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2012	8,687	12,766	323	59	15	39.8	58.4	1.5	0.3	0.1
2013	7,601	13,869	337	27	15	34.8	63.5	1.5	0.1	0.1
2014	8,606	12,866	336	26	15	39.4	58.9	1.5	0.1	0.1
2015	7,245	13,982	523	84	15	33.1	64	2.4	0.4	0.1

Table A2: River red gum woodland.

Year	Area in condition class (ha)					Proportion in condition class (%)				
	Good	Moderate	Poor	Degraded	Severely degraded	Good	Moderate	Poor	Degraded	Severely degraded
2009	1,070	2,902	245	3	10	25.3	68.6	5.8	0.1	0.2
2010	975	2,751	471	21	12	23	65	11.1	0.5	0.3
2011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2012	1,171	2,743	294	11	11	27.7	64.8	7	0.3	0.3
2013	1,093	2,832	288	7	11	25.8	67	6.8	0.2	0.3
2014	1,206	2,711	296	6	11	28.5	64.1	7	0.1	0.
2015	1,020	2,784	402	13	11	24.1	65.8	9.5	0.3	0.3%